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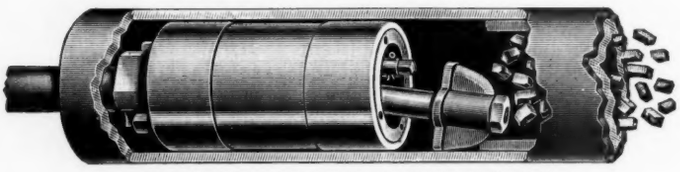

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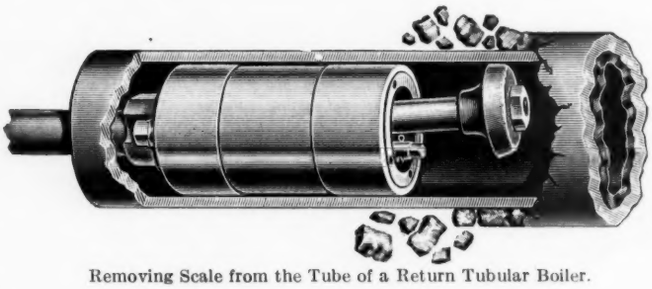

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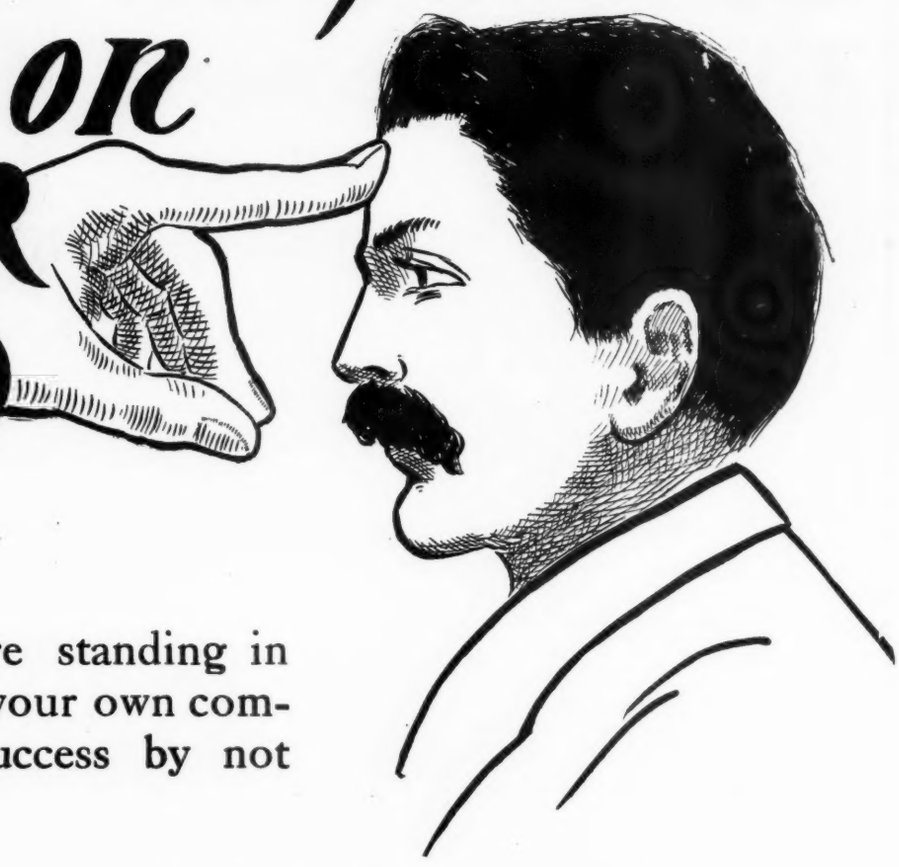

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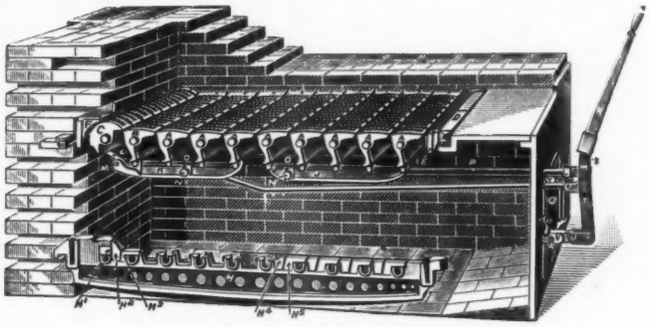

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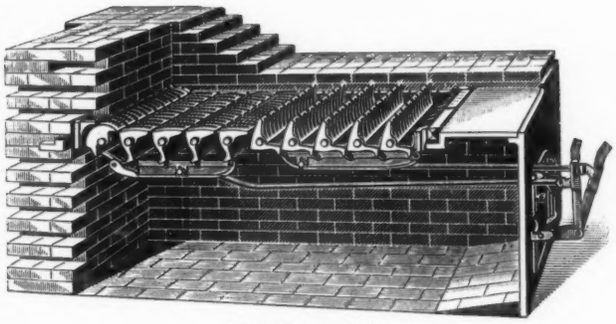
Any Fuel Is Good

On The McClave Grate Used With The Argand Blower

Shaking Movement



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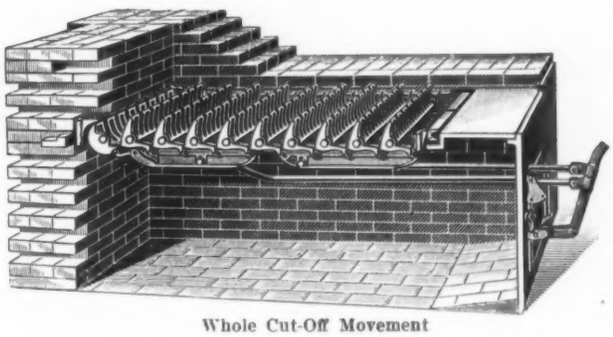

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An Interurban Railway Gas Power Station

Description of the Western New York and Pennsylvania Traction Company's Power Plant Equipment, with Notes on Its Performance

BY CECIL P. POOLE

The Western New York & Pennsylvania Traction Company, operating about 85 miles of interurban road in the vicinity of Olean, N. Y., several months ago indicated its faith in gas power by discontinuing its steam stations, one of which has been dismantled, and depending entirely upon a gas-engine station at Ceres for the power necessary to drive its cars. The station is equipped with two tandem double-acting Westinghouse engines and one twin tandem double-acting Snow engine, all of equal rating and each driving a 300-kilowatt General Electric three-phase alternator at 150 revolutions per minute.

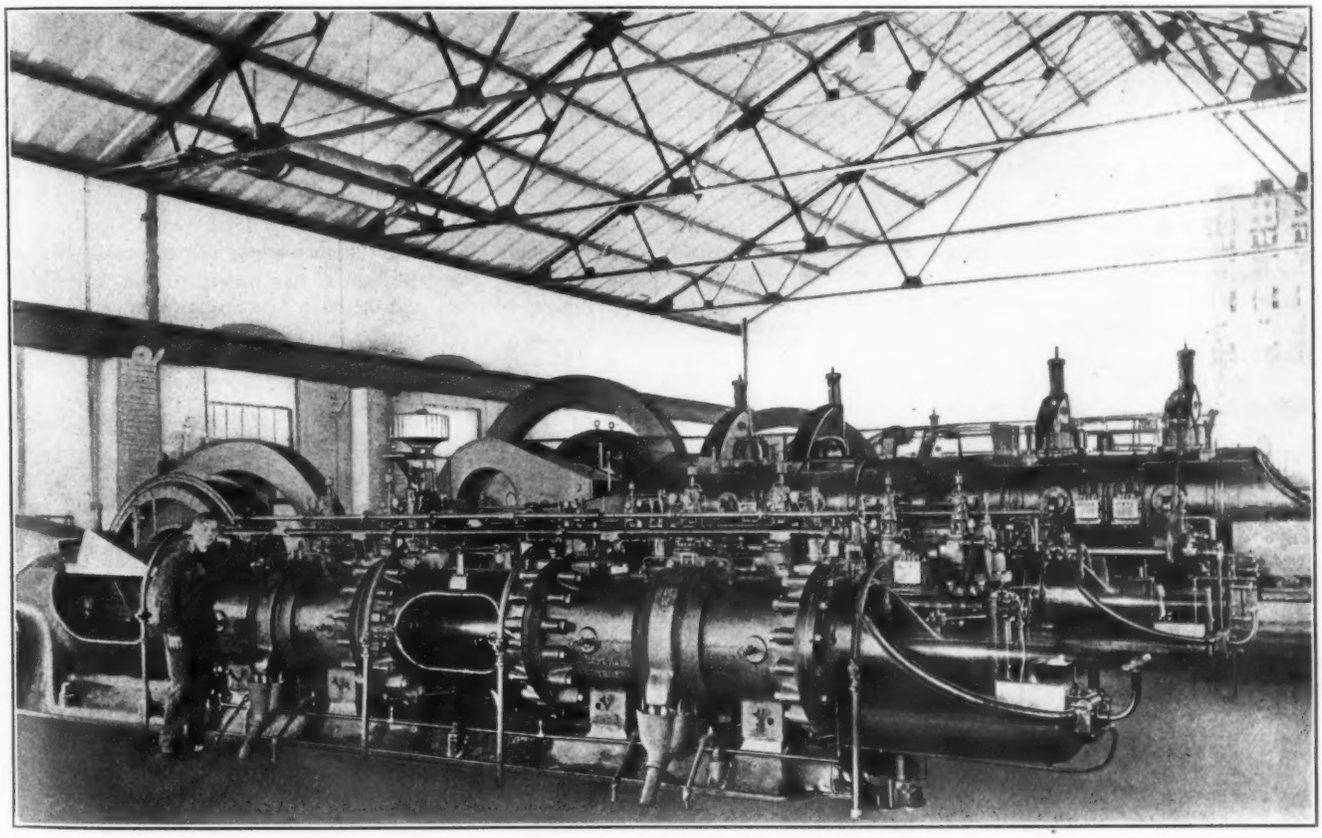


FIG. 1. ENGINE ROOM OF CERES POWER STATION

The Westinghouse Engines

The Westinghouse engines have cylinders 22 inches in diameter and 30 inches stroke and are of exactly the same type as the Edgar Thompson engines at Bessemer, Penn., described in this paper April 28. The governors of the Ceres engines are located differently from those of the Bessemer engines and are gear-driven instead of belted, but the valve-gear is identical in design, regulation being effected by having the governor adjust the quantity of gas and air admitted to the mixing chamber. The same electromagnet igniters are also used on the Ceres engines, but there is only one igniter in each end of the cylinder, the latter being only 22 inches as compared with 40 and 42 inches in the Bessemer engines. Ignition current for the Westinghouse units is supplied by a small motor-generator operated by current taken from the exciter circuit; the object in interposing the motor-generator was to avoid grounding the exciter system.

The Snow Engine

The Snow twin unit has cylinders 16 inches in diameter and a stroke of 30 inches. The two cranks are set 90 degrees apart, giving four impulses to the crankshaft per revolution, as in a cross-compound steam engine. The engine has the side combustion chamber characteristic of the Snow design, with the inlet valves in the top and the exhaust valve in the bottom of each combustion chamber. The low center of gravity obtained by this arrangement is emphasized by the comparison of this engine with its station mates. Fig. 1 is a view in the station, taken not for the purpose of this comparison, but because it was impossible to get a view of all the engines from any other point. The Snow engine, in the foreground, obviously stands much lower than the Westinghouse engines, in the background; the relative hights are also shown by the elevation drawing at the right of Fig. 2.

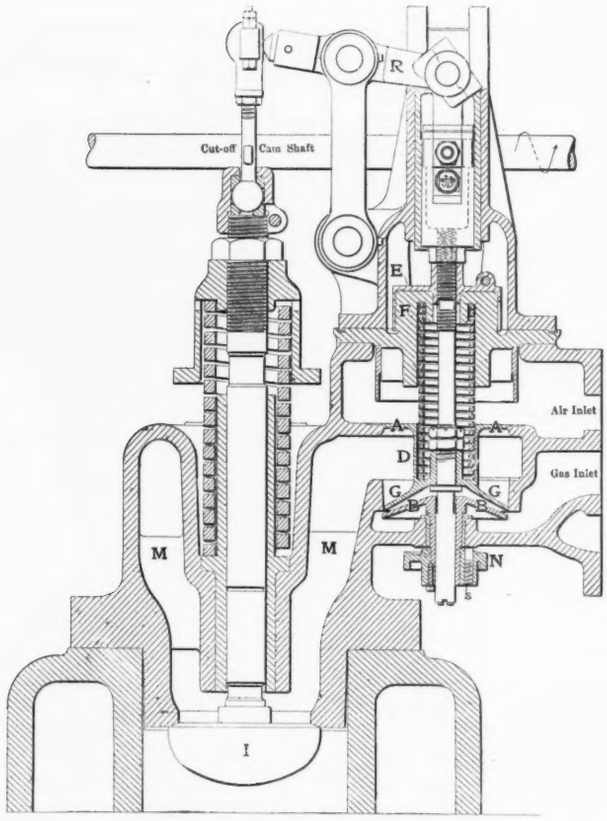


FIG. 3. SECTIONAL ELEVATION OF INLET AND CUT-OFF VALVES AND GEAR

The engine speed is regulated by cut-off valves which, under control of the governor, shut off both the gas and air supply sooner or later in the suction strokes, according to the speed changes. The arrangement of inlet valves for one end of a cylinder is shown by Fig. 3. The air and gas pass to the mixing chamber *M* through separate ports, shown closed by the valve disks *A* and *G*, respectively. From the mixing chamber the mixture is admitted to the cylinder by the main inlet valve *I* at the beginning of the suction stroke; at the point in the stroke determined by the governor, the cut-off valve *A G* is released and allowed to close under the influence of its spring. The baffling disk *B* is adjustable so as to obtain the desired proportion of gas to air, the adjustment being made by means of the nurled head *N*, which is locked in the proper position by the set-screw *s*. The shank of the baffling disk serves also as a guide for the lower end of the stem of the cut-off valve. The valve disks *A* and *G* are connected by a short barrel *D*, the whole being a single casting. The gas valve *G* is provided with a tapered seat, and the valve-stem is adjusted in the block at its upper end until both disks seat simultaneously.

The main inlet valve *I* is opened and closed always at the beginning and termination of the suction stroke by the inlet rocker-arm (Fig. 4), and its stem is linked to a short rocker-arm *R*, Fig. 3, to the other end of which is pivoted a block arranged to slide vertically in a guide. To this block is hung the pivoted latch *L*, shown in Fig. 4, the end of which normally engages a dog on the block which is screwed on the upper end of the stem of the cut-off valve. When the main inlet valve is opened, the latch *L* lifts the disks *A* and *G* of the cut-off valve. At the proper point of the suction stroke, the cam *C*, on Fig. 4, engages a lug and draws the drag-link over, thereby pulling out the latch *L* and allowing the cut-off valve to drop. The drag-link is pivotally attached to a lug on the latch *L*, and its other end is curved around the cut-off shaft *S*, the upper leg of the bend resting on the journal box and holding the link in place as it slides back and forth. Before the succeeding suction stroke begins, the cam *C* has turned to the "low" side and the latch *L* is thrown into engagement

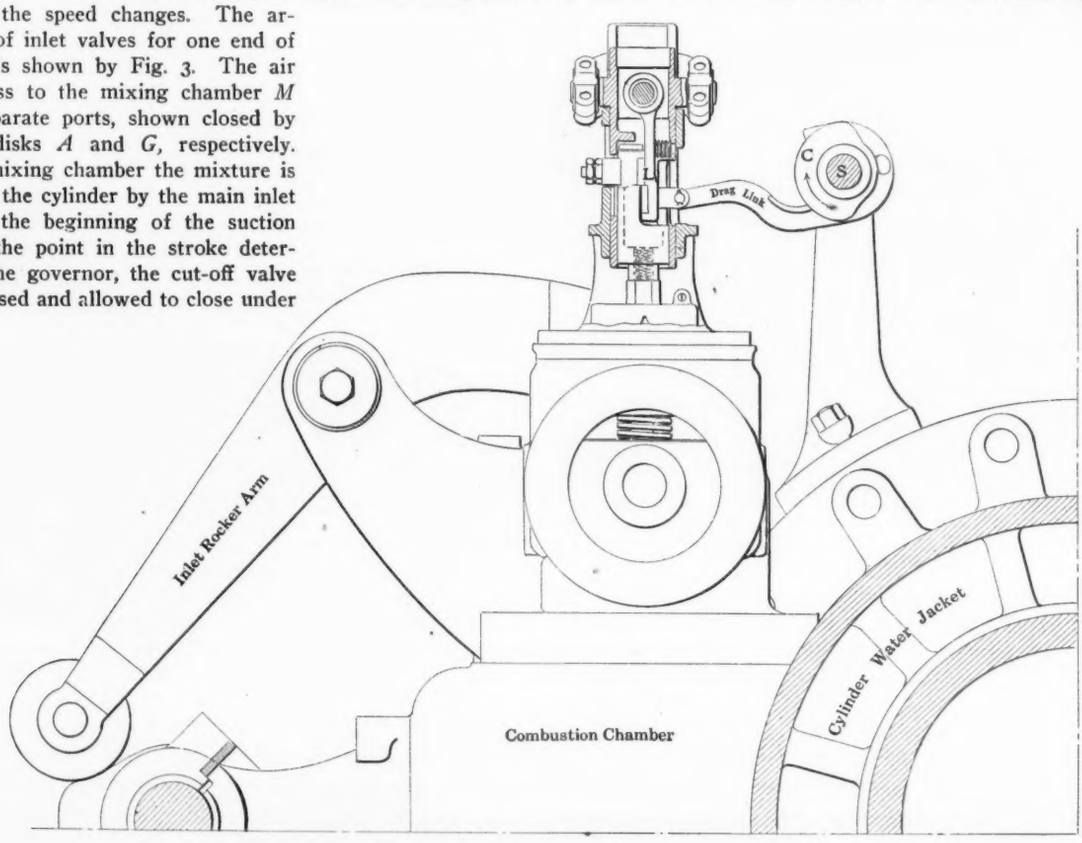


FIG. 4. END ELEVATION OF INLET AND CUT-OFF MECHANISM

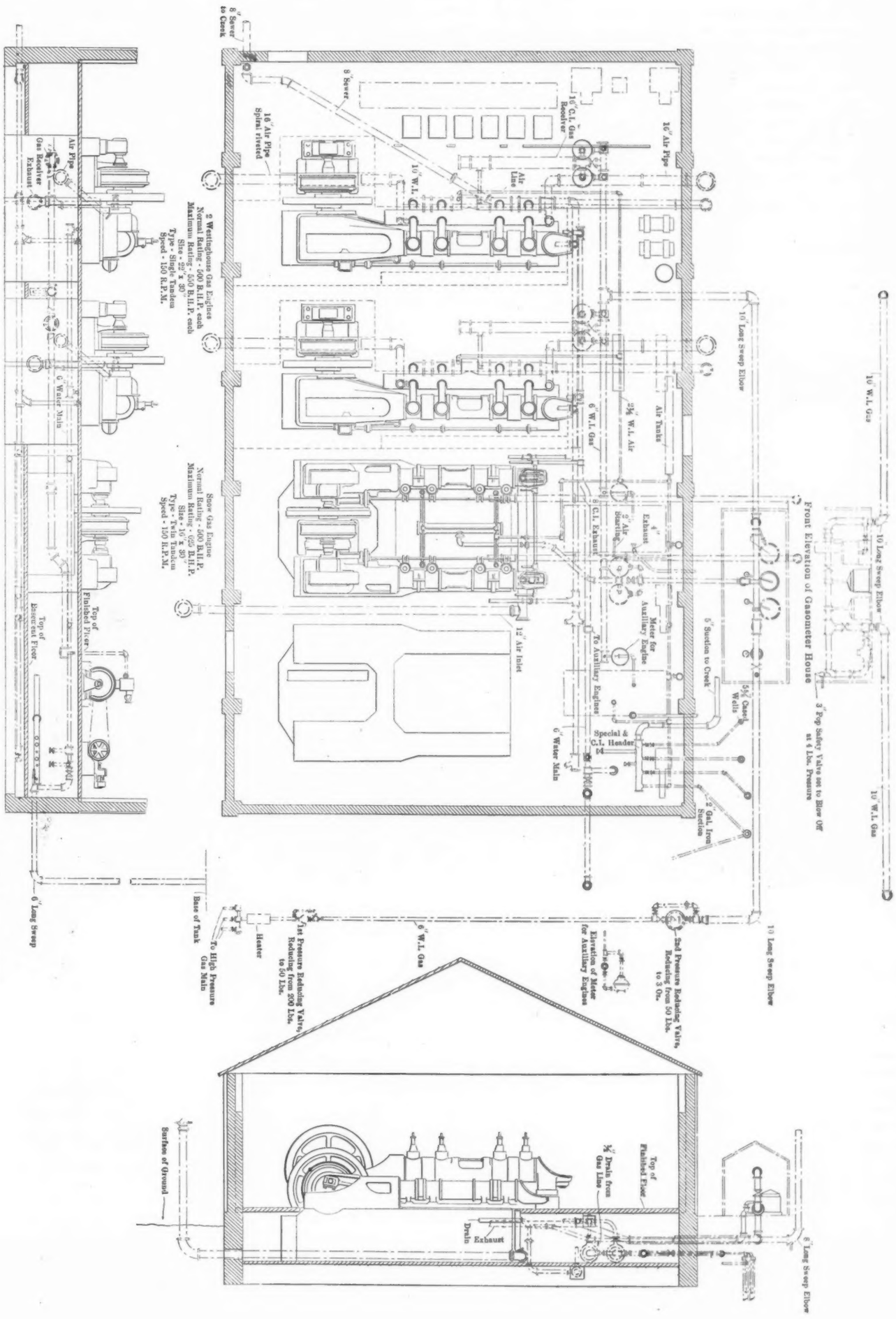

8" Sewer to Creek
8" Sewer
16" Air Pipe Spiral riveted
16" C.I. Gas Receiver
16" Air Pipe
10" W.I. Air Line
2 Westinghouse Gas Engines
Normal Rating - 600 B.H.P. each
Maximum Rating - 800 B.H.P. each
Size - 22" x 30"
Type - Single Tandem
Speed - 150 R.P.M.
Snow Gas Engine
Normal Rating - 600 B.H.P.
Maximum Rating - 950 B.H.P.
Size - 16" x 30"
Type - Twin Tandem
Speed - 150 R.P.M.
10" Long Sweep Elbow
6" W.I. Gas
2½" W.I. Air
Air Tanks
6" C.I. Exhaust
Exhaust
2" Air Starting
12" Air Inlet
Meter for Auxiliary Engine
To Auxiliary Engines
6" Water Main
Special & C.I. Header
14
5½" Check Wells
6" Suction to Creek
2 Gal. Iron Suction
Front Elevation of Gasometer House
3" Pop Safety Valve set to Blow Off at 4 Lbs. Pressure
10" W.I. Gas
10 Long Sweep Elbow
Air Pipe
Gas Receiver Exhaust
6" Water Main
Top of Finished Floor
Top of Basement Floor
6" Long Sweep
Base of Tank
To High Pressure Gas Main
Heater
1st Pressure Reducing Valve, Reducing from 200 Lbs. to 50 Lbs.
6" W.I. Gas
Elevation of Meter for Auxiliary Engine
2nd Pressure Reducing Valve, Reducing from 50 Lbs. to 3 Oz.
10 Long Sweep Elbow
Surface of Ground
Drain
Exhaust
Top of Finished Floor
½" Drain from Gas Line
8" Long Sweep Elbow

FIG. 2. PLAN AND ELEVATIONS, SHOWING ARRANGEMENT OF APPARATUS IN CERES POWER HOUSE

with the valve-stem dog by a small helical spring. When the cut-off valve drops, it is cushioned by the inverted cup *E*, Fig. 3, acting as a dash-pot, the plug *F* constituting the plunger. The cut-off cam-shaft *S* rotates continuously at one-half the crank-shaft speed and its angular position with respect to that of the crank-shaft is adjusted by the governor through the well-known "floating" bevel gear.

Excitation, Cooling and Fuel Supply

There are two exciter units consisting of Westinghouse vertical three-cylinder single-acting gas engines of 11 inches bore and 12 inches stroke direct-connected to General Electric multipolar dynamos of 50 kilowatts each; these run at 290 revolutions per minute and supply excitation current at 125 volts.

Cooling water is taken from four 5⅛-inch and four 7⅝-inch driven wells 42 feet deep. It is circulated by two 4-inch single-stage turbine-type pumps of Worthington make, driven at 1440 revolutions per minute by Westinghouse three-phase induction motors, supplied from the station bus-bars; each motor is rated at 15 brake horse-power.

All of the engines use natural gas of about 900 B.t.u. calorific value, taken from wells owned by the traction company. The gas comes from the main at 200 pounds pressure and passes through two reducing valves in series; the first reduces the pressure to 50 pounds and the second brings it down to 3 ounces. Thence it passes to a large equalizing tank from which it goes to the engines through individual pressure regulators of the gasometer type. Fig. 2 shows the piping lay-out as at first installed, but the equalizing tank has been put in and several minor changes made since this plan was drawn. The drawing shows accurately the lay-out of the machinery, however, as well as side and end elevations of it. As this drawing indicates, all of the station piping is in the basement. The oil tanks are also located there, the oil being drawn by means of pumps on the engine-room floor.

Electrical Equipment

The alternating-current generators are General Electric standard revolving-field machines, direct-driven by their respective engines. They deliver three-phase currents at 25 cycles and 370 volts, this voltage being chosen in order to eliminate transformers between the bus-bars and a rotary converter in the generating station. Step-up transformers raise the voltage to 19,100 for the transmission lines to the other sub-stations. It might seem that less expensive equipment could have been obtained by using a somewhat lower transmission voltage and winding the generators for the transmission voltage, thereby obviating the step-up transformers but using step-down transformers for the local rotary converter. The extra expense for high-potential generators and the heavier feeders necessitated by reducing the transmission voltage, however, would have almost balanced the saving in transformers, and there would have been the familiar disadvantages of the high-potential windings on the generators, which are now absent.

There are four sub-stations, the principal one at Olean, 13 miles from the power-house, whence the transmission feeders radiate to the other three sub-stations; another at Bradford, Penn., 21 miles from Olean, a third at Little Valley, 22 miles from Olean, and the fourth at Seneca Junction, 11 miles distant. The Olean and Bradford stations contain two rotary converters each, supplied from air-blast transformers connected in delta. The Seneca Junction and Little Valley stations contain one converter each, supplied from two transformers connected in V or so-called "open delta," in order that the transformer capacity may be somewhere near the converter capacity without using different sizes of transformer. All of the transformers are rated at 220 kilowatts each and the converters are all 300-kilowatt machines.

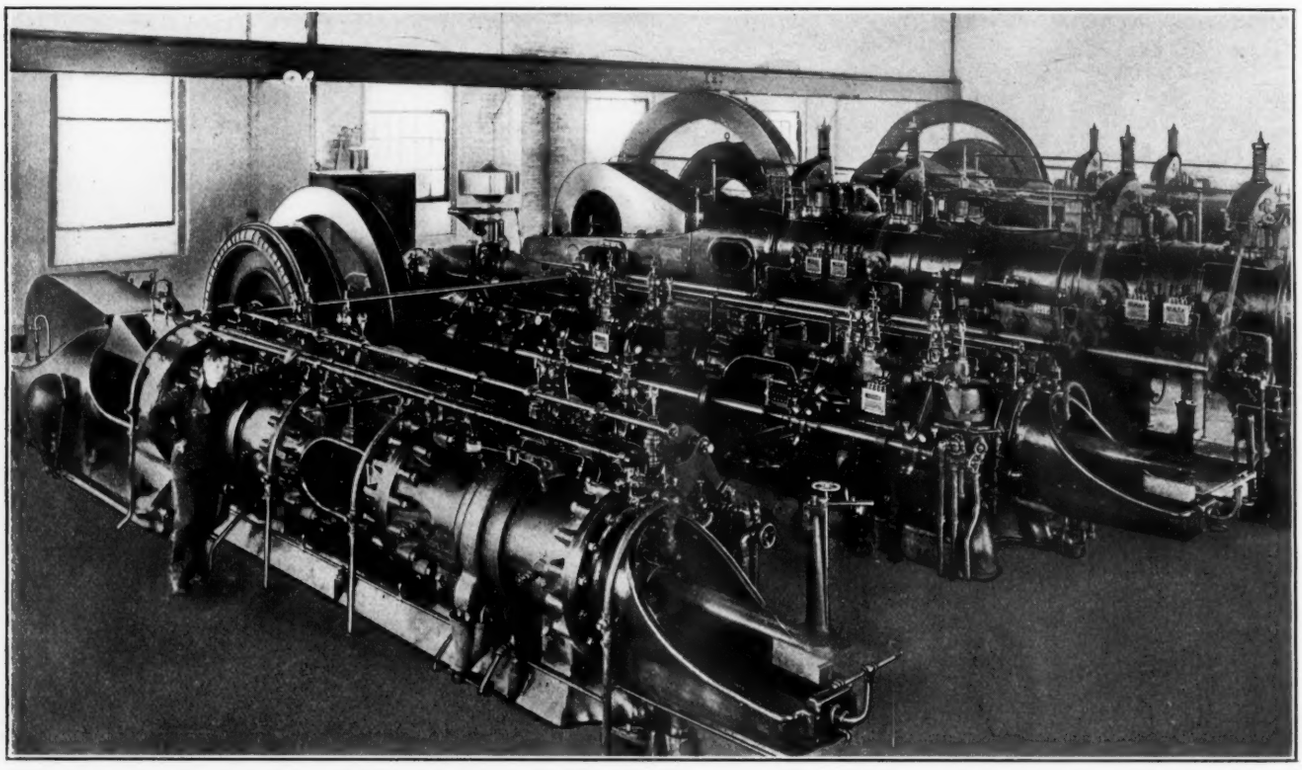


FIG. 5. VIEW OF CERES ENGINES FROM THE CRANE

Fig. 6 shows the power-house switchboard, the low-tension panels being in the center and the high-tension panels to the extreme left. The lightning arresters and choke coils appear above the switchboard on the wall. All switches in the power-house and sub-stations are manually operated. The rotary converters are started up on the alternating-current side through half-voltage taps in the transformer secondaries.

Service Performance

Fig. 7 is a typical load "curve" or, more

accurately, straight-line record of averages, the load from hour to hour being averaged, as indicated by the horizontal lines of the "curve." As this chart shows, the plant is shut down from 2 to 4 o'clock in the morning and the peak period occurs just before noon.

The Westinghouse engines have been running about a year, but the Snow engine has been in commission only a few months. Until very recently there have been no meters in the supply pipes of the Westinghouse engines, and the gas consumption therefore cannot be given in this article; we hope to publish the record later. The gas record of the Snow engine for one week was as follows:

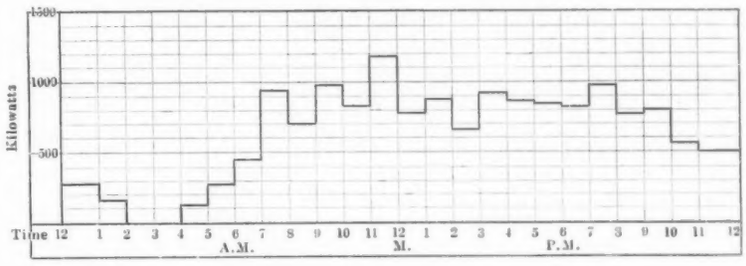


FIG. 7. TYPICAL LOAD RECORD AT CERES STATION

Day.	Hours Run.	Kilowatt-hours.	Average Load, Kilowatts.	Total Cubic Feet of Gas.	Gas per Kilowatt-hour.	B.t.u. per Brake Horse-power-hour.*
Sunday	21	4040	192.4	109,960	27.2	16,320
Monday	20	5050	202.5	127,530	25.2	15,120
Tuesday	21	4890	232.9	116,400	23.8	14,280
Wednesday	19	4730	248.9	106,310	22.5	13,500
Thursday	18	5050	280.5	111,610	22.1	13,260
Friday	20	5120	256.0	114,060	22.5	13,500
Saturday	19	5180	272.6	115,060	22.2	13,320

*Assuming 900 B.t.u. per cubic foot and 1½ brake horse-power per kilowatt.

In considering the above figures it should be borne in mind that the heat quality of the gas and the average efficiency of the generator are assumed. When it is remembered, however, that the unit ran during the larger part of each day with much less than full load, the heat consumption does not appear to be at all excessive; the assumed heat value and generator efficiency, therefore, do not seem to be seriously inaccurate.

There have been some troubles, naturally, but none that were due to the use of gas engines, excepting unreliability of igniter operation in the Westinghouse engines, which the builders promptly remedied, and rod-packing troubles on both makes of engine. The troubles with the Westinghouse rod packing had been corrected and those with the Snow rod packings were about to be corrected when the writer was at the plant. A most interesting development at this plant was the effect which the point of oil delivery to the rod packing appears to have upon the kind of oil necessary. When the oil is fed to the rod immediately outside the packing gland, it is necessary to use a very thin grade in order to prevent the innermost packing ring of the group from running dry and cutting. On the other hand, when the oil is delivered at the center of the packing, a heavier oil and one of very high flash-point must be used.

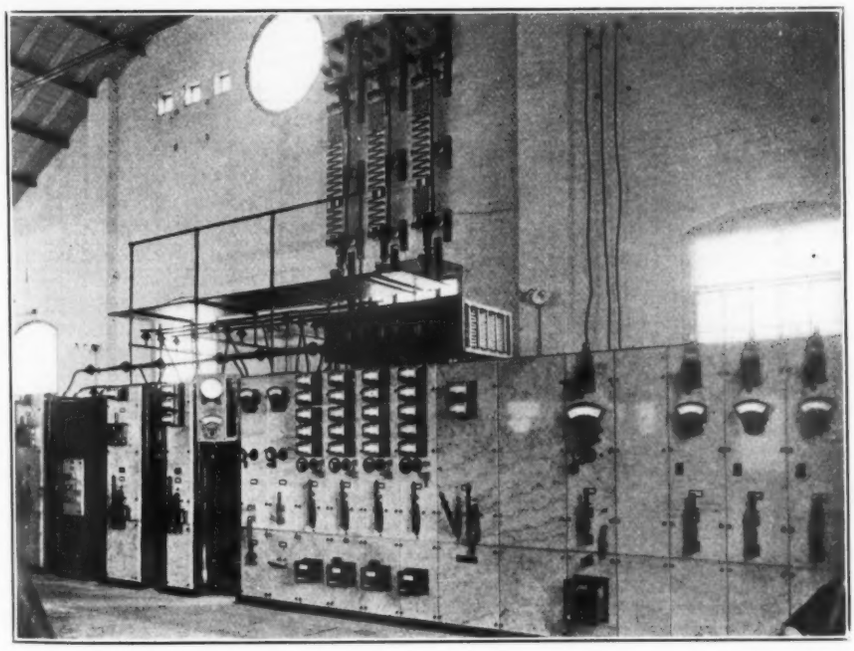


FIG. 6. THE SWITCHBOARD IN THE CERES PLANT

The total kilowatt-hours delivered by the generators during the week covered by the table were 104,340 and the total oil consumption was 18 gallons of cylinder oil and 12 gallons of engine oil. These figures reduce to less than 0.0014 pint of cylinder oil and 0.00094 pint of engine oil per kilowatt-hour.

The Snow and Westinghouse engines drive their generators in parallel with remarkable smoothness considering the difference in the crank efforts of the two types. The regulation so far as it affects the generator voltage is excellent, but there is considerable shifting of load between the machines on account of the difference in crank effort and also on account of different governor characteristics. The Snow engine takes too much of the load at light loads, partly because the Westinghouse engine occasionally misses fire at such loads and also because the governor on the Snow engine does not regulate quite so closely. The consequence is that when the load suddenly drops, the ammeters swing oppositely—the one downward and the other slightly upward. Notwithstanding these sudden and frequent changes in load distribution, the engines peg along as though they were driving independent loads. Only by watching the ammeters or the governor linkages is it possible to detect changes in load or in distribution of load.

The writer is indebted for much of the information presented herein to Thomas Cruthers, Jr., who erected both the Westinghouse and the Snow engines, and M. Silverman, chief engineer of the traction company.

"Liconite" is the name of a rubber substitute manufactured in Holland. It is similar to rubber in appearance and in many of its qualities. It is a compound of bitumen and various oils, has neither rubber nor gutta-percha in its composition, is elastic and tough, and is said to be non-hygroscopic, unaffected by water, dilute acids, or alkalis, and capable of withstanding all ordinary temperatures without flowing or cracking.

On opening up a boiler in which kerosene has been used, be careful to have no lights in or near it until it has been thoroughly aired out.

The Cost of Power

By W. N. Polakow

To determine accurately the cost of power, every detail of expense must be properly accounted for; otherwise, the total amount expended will be nothing more than the sum of a mass of indefinite expenses. The correct method of determination must clearly and immediately show the amount of, and the reason for, each indirect expenditure, giving thereby a clear idea of the economical control and opportunities for betterment of the power plant. It must make possible the comparison of the cost of power, no matter where or under what conditions the power is produced. It must give an exact answer to each of the following questions:

1. Does producing any kind of power cost too much?

2. In which period of the production and transmission of power are there unproductive expenses, and why?

3. How and in what relation does the cost of producing power vary?

Detailed Grouping of Costs

In order to answer these questions, we cannot limit ourselves to the primitive and inaccurate method of finding the relation between the totals of fuel burned, money spent and power produced. Neither should we compare such figures with the same incorrect or accidental figures of last month or last year, to ascertain whether power is produced at a less or greater cost today.

The actual total cost of producing power is made up of four major items: Rent, administration, operation, and maintenance. The total of these four accounts may be subdivided under four headings showing the absolute cost or percentage cost of each kind of power produced, viz, steam, electric, pneumatic or hydraulic. The total cost of power is charged to the shops in proportion to their consumption, and goes into the shop expenses under the heading "Power."

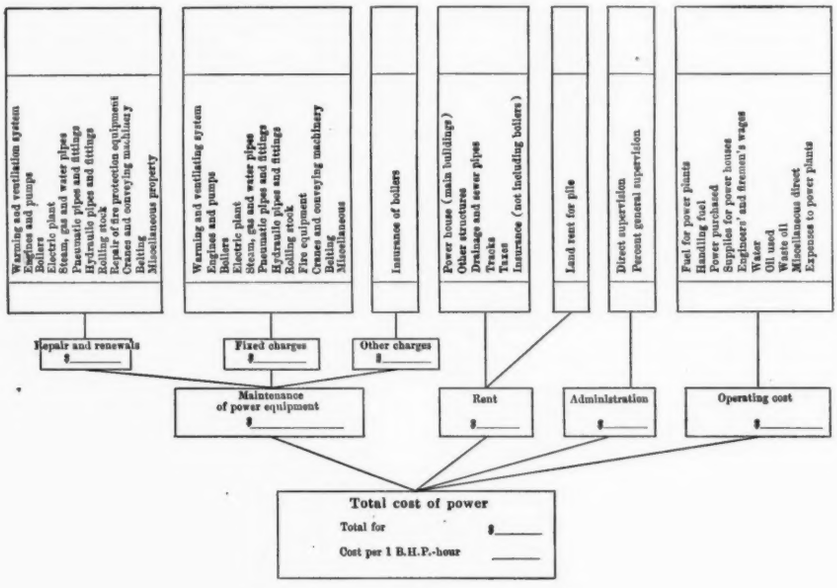


FIG. 1. COSTS OF POWER CLASSIFIED

Rent

Land rent may be figured generally for the whole plant and charged to power in proportion of the area occupied for power purposes to the total rent area. Rent of buildings may be figured on the basis of the valuation of the buildings used for power purposes. It would not be correct to pro-rate the building rent on a basis of floor space, because usually buildings used for power purposes far exceed in value buildings of an equal floor space that are used for general manufacturing purposes.

Administration.

Administration expenses charged to power may be taken as an arbitrary per cent. of the amount for the whole plant. Under this heading are charged all expenses which do not properly belong either to rent, operation or maintenance, such as watchmen, stationery, etc.

Operation

Under this heading are included all expenses for the following accounts: Fuel for power plants, fuel for other boilers, fuel for yard engines and cranes, handling fuel, miscellaneous supplies, lubricating materials, water for boiler and waterbacks, engineer's, firemen's and helper's wages, power purchased.

A diagram should be drawn showing the consumption of fuel by month and 12-months average, also a diagram showing the cost of fuel on the same basis.

Maintenance

This heading includes the three following groups of expense: (A) Repairs and renewals, (B) fixed charges, (C) other charges.

Group (A) includes all expenses for repairs and renewals of power equipment, whether used for production or transmission, and each item of expense should be charged to one of the following accounts: Boilers, engines and pumps, electric plant, steam, water and gas pipes, pneumatic pipes and fittings, hydraulic pipes and fittings, warming and ventilating systems, rolling stock (10 per cent).

Group (B) includes such items as depreciation, interest on investment, etc.

In a system of accounting based on the above foundation, it is comparatively easy to locate a leak affecting economy or efficiency, such as expensive repairs or unnecessary expense for lubrication, but alone it cannot give an exact idea of the quality of the general management.

Plants / Power Delivered		East Side				West Side				Pumping Plant				All Plants		
		No. of B.H.P.-Hrs. Equal 1 Unit	Monthly Total Power Delivered	Monthly Total Cost	Cost per Unit	No. of B.H.P.-Hrs. Equal 1 Unit	Monthly Total Power Delivered	Monthly Total Cost	Cost per Unit	No. of B.H.P.-Hrs. Equal 1 Unit	Monthly Total Power Delivered	Monthly Total Cost	Cost per Unit	Monthly Total Power Delivered	Monthly Total Cost	Average Cost per Unit
Live Steam Unit: B.H.P.-Hrs.	B.H.P.-Hrs.															
Electric Power Unit: K.W.-Hrs.	Generated K.W. Hrs.															
	Generated B.H.P. Hrs.															
	Purchased K.W. Hrs.															
	Total															
Electric Light Unit: K.W.-Hrs.	Generated K.W. Hrs.															
	Generated B.H.P. Hrs.															
	Purchased K.W. Hrs.															
	Total															
Compressed Air Unit: Cu. Ft. Free Air per Min. at 100 # □"	Cu. Ft. Free Air per Min. at 100 # □"															
	B.H.P.-Hrs.															
Hydraulic Power Unit: 1 Gal. per Min. at 100 # □"	Gallons per Minute at 100 # □"															
	B.H.P.-Hrs.															
Total Power Delivered to Works	B.H.P.-Hrs.															
Total Power Generated in Plant, Based on Coal Burned; Unit: Tons Coal Burned per Month																

FIG. 2. UNIT COSTS

Unit Cost

It is necessary to know the actual cost of producing a unit of each kind of power.

Since all kinds of power are derived by various transformations from the same or similar sets of boilers, there should be weekly and monthly statements showing the amount of water evaporated per pound of fuel, also the pounds of fuel per brake horse-power. The cost per brake horse-power of the steam produced is the base of all figures on the cost of operation in the production of power. Any excess cost here, any inefficiency, such as a poor up-keep or uneconomical handling of fuel, would cause the unit cost of each kind of derived power to be higher than it should be.

Figures on unit cost are obtained from a statement similar to Fig. 2, with figures of recording meters giving daily, weekly and monthly amounts of brake horse-power produced, for live steam per brake horse-power-hour, for light and power, cubic feet of air, or gallons of water per minute under constant pressure, etc.

Having these figures of the cost of a power unit, we only have the raw material, but by observing these figures we have a foundation for judging as to whether the enterprise is run on an economical or non-economical basis; the expressions "warm" or "warmer" would not give an idea of temperature until there is fixed a certain basis from which to measure.

Standard Unit Cost

An authority on this question, Harrington Emerson, says: "It is impossible to make comparison unless there is something with which to compare, and it is more rational, more correct, more instructive to compare with a determined standard than to compare with last week's or last year's accident, and nothing can be more profitably instructive than to compare local standard cost, line by line, with the basic standard cost and the actual expenses, in order to get busy according to what would be correct and enduring, or otherwise overcoming handicaps beyond individual control."

We must have a standard unit cost for a base and make all comparisons against it. Herein we have to the same degree of accuracy that our standard unit cost has been figured, a measure of the efficiency of the plant.

Standard unit cost may be considered to be formed of two distinct parts, and may be expressed as

$$S = T + O$$

where T includes that group of expenses relating to the theoretical transformation of energy from heat to some other definite form. It is figured once for all as a general standard cost independent of local or construction conditions.

For example, in the generation of electric energy, for every 100 units transmitted from the switchboard, we figure, the:

1. Least resistance in the switchboard.
2. Least resistance in the generator.
3. Least loss in the engine.
4. Least loss in the steam piping.
5. Least loss of heat from fuel while generating steam.

In this way, taking everywhere the most advantageous coefficient, we are certain of the quantity of kilowatt-hours per unit of fuel, or the standard cost of one kilowatt expressed in units of fuel.

The second part O of the formula includes the least possible cost of all other expenses of operation per unit of a certain kind of energy. Here again we have not only a correct idea of the efficiency of operation, comparing the standard cost and the actual expenses, but we can compare and determine at any time the source of unproductive expenses. Comparing the results from the formula

$$S = T + O$$

with results from

$$S' = T' + O',$$

we can direct our efforts without loss of time or guessing, either to the technical or business improvement of the plant.

In determining the cost of power produced for sale, the total must include, of course, all expenses, even to the cost of advertising and selling, the total cost differing from the selling price by a fixed amount which will be the per cent. of profit.

From the foregoing it is clear that only by such preparatory work and with the actual figures for as long a period of time as possible in the form of 12-month averages, in order to eliminate accidental fluctuations, is it possible efficiently to carry out the work of bettering the power plant and lessening the cost of power generation. The work must be done carefully and systematically, not losing sight of one moment of operation in the production and transmission of power, taking for granted that each step made is erroneous and uneconomical, and giving special attention to places where errors were discovered by previous analysis.

Society for the Promotion of Engineering Education.

The 16th annual meeting of this society was held at Detroit, Mich., June 24 to 27, inclusive, at the same time the A. S. M. E. meeting was held. The program included a number of papers, among them the following: "A Proposed Course in General Engineering," by Harwood Frost; "Present Curricula of the Mechanical Engineering Courses," by Prof. William T. Magruder; "The Function of the Engineer in the Conservation of the Natural Resources of the Country," by Charles S. Howe; "Adapting Means to the End in Technical Education," by Arthur L. Rice; "Electrical Laboratory Efficiency," by S. Sumner Edwands; "Entropy," by Prof. W. D. Ennis; "Should the Engineer be Required to Hold License?" by Prof. W. H. Drane.

Catechism of Electricity

718. *Can compound-wound dynamos be operated in multiple satisfactorily?*

Yes. Multiple operation is the standard method of working two or more compound-wound dynamos together. The connections are shown diagrammatically in Fig. 243. The equalizer, which maintains an equilibrium between the electromotive forces of the two machines, is the principal feature to consider. It consists of two heavy wires, g and g', running to an extra bus-bar h, which connects them and thereby completes the equalizing circuit. The equalizer circuit is carried to the switchboard in order that it may be closed and opened at the same time the machines are connected with or disconnected from the main bus-bars.

Care must be taken to connect the equalizer to the junctions between the series windings and the brushes of the machines, not to the outer terminals of the series windings. To insure good regulation, the equalizer must have ample current-carrying capacity; it should never be smaller than the main leads of the dynamos.

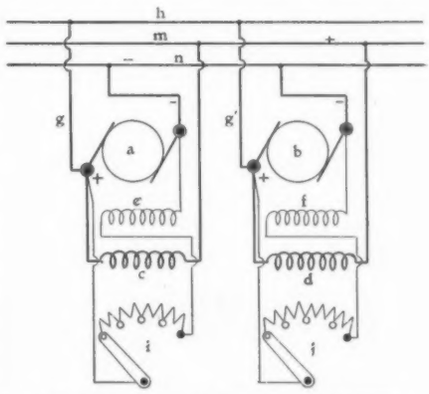


FIG. 243. DIAGRAM OF TWO COMPOUND-WOUND DYNAMOS CONNECTED IN MULTIPLE

719. *What precautions are necessary in operating compound-wound dynamos in multiple?*

Before switching them together the voltages must be nearly alike, the voltage of the unloaded machine being a fraction higher than that of the one already in use. If the equalizers run to the main switches on the board no attention need be paid to them, as they will be connected at the same time the machines are thrown together. If, however, the equalizing wires are separate, care must be taken to close the equalizer switches before the machines are thrown together.

With compound-wound dynamos, the terminals of both machines to which the shunt resistances across the series windings are fastened must be connected to the same bus-bar. Then if the polarity of the dynamo is wrong, it must be corrected by exciting the field properly with current from another machine. Care must

be taken not to open the equalizing circuit of two compound-wound generators while they are running in multiple.

720. *Show a switchboard equipped for operating two compound-wound dynamos in multiple.*

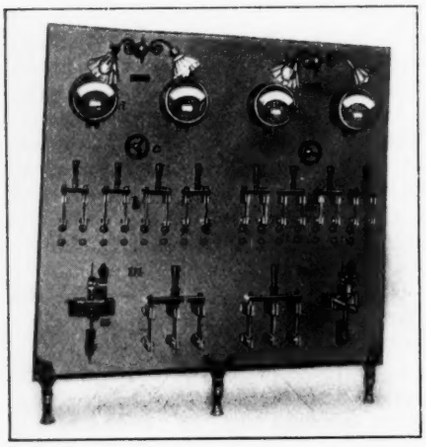


FIG 244. TWO-PANEL SWITCHBOARD EQUIPPED FOR OPERATING TWO COMPOUND-WOUND DYNAMOS IN MULTIPLE

Fig. 244 shows such a switchboard. All of the apparatus belonging to one of the dynamos has been placed on the left-hand panel *m*, and all that belonging to the other dynamo has been mounted on the panel *n*. At *a* is shown a circuit-breaker, and to the right of this, a three-pole switch the middle blade of which is in the equalizer circuit. The ammeter and voltmeter are near the top at *d*, and above these are the switchboard lamps. The field rheostat is located at *c*. At *b* and *b* are groups of four switches on each panel; these are used to close and open the eight circuits that are supplied with current from the bus-bars.

721. *Is the apparatus on a board arranged differently from that shown in Fig. 244 when provision is made for more than two compound-wound dynamos?*

Not in principle. The switchboard shown in Fig. 245, for example, which is equipped for operating four compound-wound dynamos in multiple, has practically the same arrangement of apparatus as on the board in Fig. 244. A three-pole switch *s* is provided for each machine; also a field rheostat *t*, and an ammeter, *m*. The feeder switches are shown also. Instead of having a voltmeter for each dynamo, however, only one voltmeter is used for all. The voltmeter switch at *a* enables this to be done by permitting the voltmeter *d* to be connected to any of the circuits.

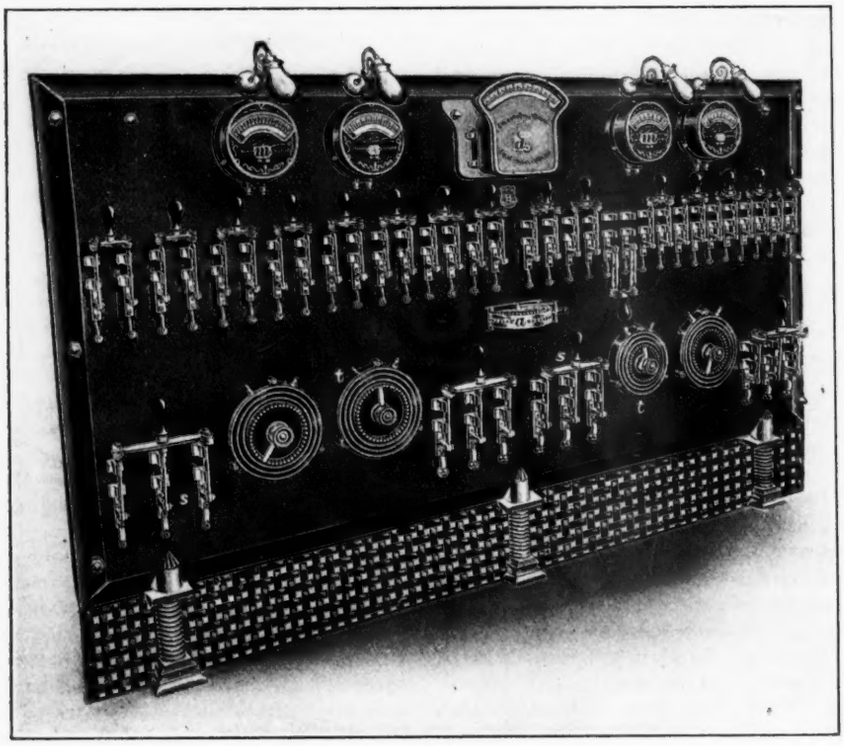


FIG. 245. SWITCHBOARD EQUIPPED FOR OPERATING FOUR COMPOUND-WOUND DYNAMOS IN MULTIPLE

Observations on Gas Producers for Power Use

By F. C. Tryon

There are few things of real value that are obtained without some struggles and worries, and this is especially so in power-generating plants. With steam boilers and steam engines we are fairly well acquainted; their care and attention, with all the varied troubles, have been accepted as a part and parcel of their operations, but an entirely wrong impression seems to pervade the minds of many people regarding a producer gas plant.

This impression was probably first produced and spread by some of the manufacturers of this type of apparatus, who ignorantly described their products as requiring little or no attention, and assured the prospective purchaser that with a certain amount of coal fed to a producer in the morning, and a few ashes removed at night, the plant would run itself. This same class of manufacturers have sent into the field salesmen who are not only not thoroughly posted regarding the process of gas production in general, but actually know very little about the apparatus they are trying to sell, and still less of the mechanical operations necessary to produce such chemical changes as are required in an outfit of this kind. These sellers made all kinds of statements and promises to secure signatures to a contract, which the purchaser later found, when more carefully read, repudiated all statements and promises not specifically provided for in the document itself.

The "Easy of Operation" Claim Often Overdrawn

The flowery story of easy operation pictured and described before purchase, often turns out to be a tale of constant and careful detailed attention. The producer plant must have attention as early in the morning as boilers would require. The blower or exhauster must be started early enough to get the fire in proper condition for making gas by the time it is necessary to start the engine, and the proper amount of fuel fed to the producer to get the plant in operation. When the fire is in proper condition for making gas it must be barred or poked to get the ashes loosened from the partly consumed pieces of coal, and all clinkers worked down out of the fuel bed, because clinkers in the bed of fuel offer passages for the air without its coming in contact with sufficient carbon to absorb the oxygen of the air and generate carbon monoxide gas. If this combination does not occur during the passage of the air through the bed of fuel a different combination results immediately above the fuel bed by the mixing of the air with the gases already generated and burning them to carbon dioxide, thereby giving up in the producer the heat that should be carried to the engine to do useful work.

When the producer is making a gas sufficiently good to ignite readily at the test tube, the engine is started; then the volume of steam or vapor necessary to keep the fire in the producer sufficiently cool to prevent the fusing of the ashes into solid clinker must be provided. The amount of steam thus admitted should be all that the engine will take without backfiring, provided the load on the engine is a steady one, or the steam inlet is automatically regulated by the volume of gas

the engine is using. As soon as the steam inlets have been properly adjusted, all ashes and clinkers previously barred down should be removed from the ash-pit, if the type of producer will allow this work to be done while in operation. If the producer is of either the suction or the induced up-draft type, the ash-pit door can be opened at any time for this purpose. If the producer is of the down-draft or the pressure type, the cleaning of the ashes can only be done when the engine is not running. No accumulation of ashes should be allowed in the ash-pit beyond the first opportunity allowed for its removal. In an up-draft producer where the air is admitted below the grate, if ashes fill this space it prevents the proper distribution of the air through the grate and tends to concentrate the draft of air in small spaces, causing chimneys or blow-holes through the fire-bed.

When the producer has been cleaned and the ashes removed, the necessary amount of fuel to run the producer a certain definite time should be fed into the fire-bed or, what is better still, the fire-bed built up to a certain hight. This should be determined by the operator as that depth of fuel-bed which gives him the best quality of gas for the longest period. Too deep a fire-bed may make the process of barring to work down the ashes so hard and laborious a task that it is often avoided and seldom properly done, besides unnecessarily restricting the draft.

Blow-holes through the fire-bed are usually corrected by feeding in more fuel. This is not the proper manner to cure this evil; the fire should be barred or tamped at the affected points to pack the fuel closer together and force the passage of air through the entire fire-bed. As long as the engine keeps steadily at work without back-firing and the gas is not weak, the less stirring or disturbance of the producer fuel-bed the better; too long a time between feeding and cleaning, however, should not be allowed.

Ashes in the Fire-bed

The operator should always bear in mind that the producer is gasifying regularly a given amount of coal per hour, that the coal leaves a certain amount of ashes, that these ashes are being made all through the fire-bed, and that at certain intervals, as far apart as is absolutely safe, the entire fire-bed must be stirred by barring to work the ashes down toward the grate. Do not try to get them through the grate into the ash-pit. If this is done, the hottest part of the fire in the producer would be on the grate, causing unnecessary deterioration and in many cases serious injury by the extreme heat. In an up-draft producer the zone of complete combustion should be at least a foot above the grate and the hight of the fuel above this sufficient for absolute contact of the products of this combustion with the incandescent fuel to change the CO_2 into CO. Experience with each individual producer will soon demonstrate to the operator what the depth should be to produce the best results. A fairly safe basis to start with is to have the depth of the fuel-bed equal to the diameter of the inside of the producer.

If the producer is of the induced-draft type, a test-flame tube should be installed as near as possible to the exhauster on the pressure side and kept lighted while the producer is in operation. This test flame, if properly studied, will give the operator a fairly reliable index of the quality of the gas being made. Gas of 110 B.t.u. or over will ignite and burn steadily in open air from the outlet of a pipe. When the quality gets below 110 B.t.u. it commences to flutter and burn from side to side. When it runs as low as 100 B.t.u. it will go out entirely and only burn while a flame is held in contact with the escaping gas or over the opening. If the burning gas shows an intense blue flame with small streaks of black through its body its principal components are CO and H. As the proportion of H increases, the size of the black streaks will increase. If the gas contains any CH_4 it will show in flashes of yellow through the flame; C_2H_4 will show in more intense or brighter yellow streaks; CO_2 will show a pinkish border to the flame. As it increases this color tends more to red or purple. Noting the predominating colors and shape of flame when a sample of gas is being taken for analysis and then studying the result of the analysis will soon enable the operator to determine by this test flame within a reasonable degree the quality of the gas being made. If the gas has passed through the scrubbers before reaching the test flame, the flame will show the cleanliness of the gas and its freedom from suspended impurities or solids of any kind. In the test flame the solids produce stars or flecks of bright yellow.

A gas may be rich enough to use in an engine and still not ignite or burn at the test-flame tube. If the gas has not been sufficiently cooled in its passage through the scrubbers it may carry enough vapor to prevent lighting. The feeding of more water to the wet scrubber will usually correct this difficulty. The lack of water may be caused by a stoppage in the spraying device at the top of the wet scrubber. This is liable to occur when the water used contains a large amount of solids, either in suspension or combination, or if the spray is formed by small perforations in the pipe. These become clogged or stopped, and it may be possible that a portion of the wet scrubber may not be sprayed at all and any gas passing through this part will not be washed or scrubbed.

Other Essentials to be Remembered

A properly installed producer-gas plant of either the pressure or the induced-draft type should have several connections tapped into different parts of the plant and small pipes brought from these points to the operating floor and connected to U-gages of sufficient length to show the vacuum and pressure at different places along the route through which the gas passes in the apparatus. The gages should be installed on a board in plain view of the attendant, and if the glasses are filled with colored water the indications are more easily seen at a distance.

It is essential that a producer-gas plant should yield a steady volume of gas in quantity sufficient to supply the engine and as nearly constant in quality as possible. Changes in the quality of the gas entail changes in the mixing valve of the engine and, therefore, the producer operator should study to make only such changes in the fuel-bed as necessity requires to keep it in productive condition and ready to meet sudden changes of load.

The essentials of a good producer attendant are careful attention to details, cleanliness, and sufficient interest in the work to note from day to day what movements or actions prevent or overcome difficulties of operation and also produce the best results. The appearance of a plant usually indicates the character of the attendant. If all the tools and implements are kept in usable condition and in their proper places, the floor or space around the producer kept clean, no pieces of coal or cinders or splotches of ashes left around, no coating of dust allowed to obscure the gage glasses or cover any shelves or wall projections, and the general appearance is one of neatness, it is a pretty sure indication that the attendant is looking out for his employer's interest and has the proper desire and incentive to become a thorough master of his work.

To Find the Cubic Contents of a Barrel

To find the cubic contents of a barrel, square the largest diameter, then multiply by 2, then add the square of the head diameter; multiply this sum by the length of the cask and that product by 0.2618. For example, a barrel whose largest diameter is 21 inches, head diameter 18 inches and hight 33 inches: $21 \times 21 \times 2 = 882$; $18 \times 18 = 324$; $324 + 882 = 1206$; $1206 \times 33 = 39{,}798$; $39{,}798 \times 0.2618 = 10{,}419.11$ cubic inches. Dividing by 231 for gallons gives 45.10 gallons.

The Japanese government ordered for the port of Yokohoma 61 electric cranes, varying in capacity from 1 to 75 tons. There are at present 100 hydroelectric stations at work, and several are in course of construction. Among the latter is one on the river Tamagawa, supplying Tokyo; from this station 20,000 kilowatts are transmitted at 40,000 volts. There is also one of 32,000 kilowatts in course of erection.

The Heat of Fuels and Furnace Efficiency

Heat Defined; Elements of Commercial Fuel; How Chemical Composition Determines Heating Value; Other Factors of Combustion

BY PROF. WILLIAM D. ENNIS

The first law of thermodynamics, first proved experimentally by Joule, teaches that heat and mechanical energy are mutually convertible, in the ratio of 778 foot-pounds to one British thermal unit, which is defined as that specific quantity of heat which is necessary to change the temperature of one pound of water one degree when the water is at or near its temperature of maximum density.

Heat Defined

Heat is due to molecular motion. The motive force at work in the production of heat from fuel is chemical affinity. When a chemical compound is formed, heat is evolved; and the heat of formation is defined as that quantity of heat evolved or absorbed during the formation of a compound from its elements. The heat of combustion is defined as the quantity of heat evolved during complete oxidation, or union with oxygen. When a compound body can unite directly with oxygen, its heat of formation is the difference between the sum of the heats of combustion of the constituent elements and the heat of combustion of the compound itself.

Any substance which can be made to unite with oxygen on a commercial scale is a fuel. Heat is generated by the union of elements with other substances than oxygen, but since oxygen and nitrogen are the substances universally distributed in the atmosphere, and nitrogen is nearly inert, so far as chemical combination is concerned, oxygen is practically the medium of combustion. For practical purposes it is further desirable that only those substances which form gaseous compounds with oxygen should be classed as fuels.

The heat of combustion of a fuel is determined by measuring the heat evolved during complete combustion by means of a calorimeter. Eliminating certain modifications necessary to make allowances for radiation losses, etc., the operation is essentially that of determining the elevation in temperature of a known weight of water resulting from the combustion in transmissive contact with that water of a known weight of fuel. Suppose, for example, one pound of coal to be contained by a tight vessel filled with sufficient oxygen for combustion. Let this vessel be submerged in water and the fuel ignited by an electric spark; then if the water, amounting, say, to 140 pounds, rises in temperature 100 degrees, the heat of combustion of the fuel is approximately

$$140 \times 100 = 14{,}000$$

B.t.u. The heating value of carbon burned to CO_2 is 14,500 B.t.u. per pound.

Elements of Commercial Fuel and their Heat Value

All commercial fuels are the products of vegetable growth, and are composed mainly of carbon, hydrogen and oxygen. Carbon burns with oxygen to form CO or CO_2, depending on whether the supply of oxygen is restricted or ample. In burning to CO, each pound of carbon evolves only 4450 B.t.u. Hydrogen burns with ogygen to form H_2O, or steam, evolving per pound 61,800 B.t.u. In this union each pound of hydrogen produces nine pounds of steam, and in order to prevent this steam from condensing to water, a quantity of heat equal to the latent heat of evaporation must be reserved. This amounts to

$$966 \times 9 = 8694$$

B.t.u.; which must be deducted from the heating value given, leaving 53,106 B.t.u. as the useful effect obtainable from the combustion of one pound of hydrogen. The free oxygen in fuels is not itself a fuel, but serves to decrease the amount of oxygen necessarily absorbed from the atmosphere to permit of complete combustion. Oxygen combined with hydrogen passes off as steam, and the hydrogen so combined is unavailable for combustion.

Of a fuel the heating value is the quantity of heat evolved by that fuel in uniting with oxygen. The temperature obtainable from the combustion of a fuel depends upon its heating value, and other factors to be considered later. In the case of hydrogen, the specific heat of the steam and the water formed in combustion, the latent heat of evaporation, and the quantity of steam formed must be considered. If one pound of hydrogen is caused to unite with eight pounds of oxygen, starting from an initial temperature of 32 degrees, the evolution of heat first causes the water to increase in temperature to 212 degrees, boils it and then superheats the steam. As there are nine pounds of water produced, approximately

$$9 \times 1 \times 180 = 1620$$

B.t.u. are used in increasing the temperature of the water. As already stated, 8694 B.t.u. are required for evaporation, making a total of 10,314 B.t.u. to be deducted from the 61,800 B.t.u. of heat evolved, and leaving 51,486 B.t.u. available for increasing the temperature of the steam above 212 degrees. The amount of heat necessary to raise the temperature of steam one degree is not precisely known, but taking it at 0.4805 B.t.u. per pound, as given by Regnault, the nine pounds of steam will absorb

$$9 \times 0.4805 = 4.3245$$

B.t.u. per degree, and the temperature due to combustion will be:

$$(51{,}486 \div 4.3245) + 212 = 12{,}112$$

degrees.*

In the case of carbon, burning to CO_2, the product of combustion is a gas, so that no deduction is to be made for the specific heat of the liquid or its latent heat of evaporation. Each pound of carbon unites with 2⅔ pounds of oxygen, producing 3⅔ pounds of CO_2. The specific heat of this gas is 0.2164. The rise in temperature is then

$$\frac{14{,}500}{3.67 \times 0.2164} = 18{,}200$$

degrees. Thus, although hydrogen has a heating value of more than four times that of carbon, the elevation of temperature which it produces is decidedly less. For carbon burned to CO, the weight of gas per pound of carbon is 2.33 pounds, and the specific heat being 0.245, the elevation of temperature is

$$\frac{4450}{2.33 \times 0.245} = 7800$$

degrees.

Burning in Air vs. Pure Oxygen

These calculations have dealt with fuels burned in pure oxygen. With atmospheric air, as employed in practice, the nitrogen and minor substances present increase the weight of gas produced and consequently decrease the temperature elevation. If we ignore the carbonic-acid gas and other unimportant substances contained in air, then, since air consists of 23 parts of oxygen by weight, each pound of oxygen which unites with the fuel carries with it 3.35 pounds of nitrogen, the specific heat of which is 0.244. In burning carbon to

*Professor Carpenter ("Experimental Engineering," page 450) quotes Bunsen's calculation as giving 14,542 degrees. This must have been based on the full heating value of hydrogen, viz. 61,800 B.t.u., which would give the temperature computed by Bunsen if the specific heat were taken at 0.475. Poole gives 12,108 degrees as the rise in temperature.

CO_2 the elevation in temperature is then only

$$\frac{14,500}{(3.67 \times 0.2164) + (2.67 \times 3.35 \times 0.244)} = 4870 \quad (A)$$

degrees. This is the maximum possible temperature elevation in the actual operation of steam-boiler furnaces, but is never obtained in practice. Carbon burning to CO in air would give a temperature rise of

$$\frac{4450}{(2.33 \times 0.245) + (1.33 \times 3.35 \times 0.244)} = 2690 \quad (B)$$

degrees, and hydrogen would give

$$\frac{51,486}{(9 \times 0.4805) + (8 \times 3.35 \times 0.244)} = 4750 \quad (C)$$

degrees above 212 degrees.*

In present practice successful combustion means the evolving of the largest quantity of heat and the commingling of just sufficient air to furnish the necessary oxygen for complete burning. Recent researches have shown that the rapidity of transmission of heat by radiation is proportional to the fourth power of the difference in temperature. In a steam boiler the whole aim is to transmit as much of the heat of combustion as possible to the steam, and since the interval of time in which this must be done is short (being the time required for the movement of the gases from the grate to the uptake), rapidity of transmission is essential to high efficiency. As usually considered this rapidity is only to be gained by having the furnace temperature as high as possible. Any decrease in the supply of air below the amounts previously calculated, decreases also the supply of oxygen and consequently the amount of heat evolved in combustion.

For example, in the case of carbon burned to CO: Suppose only nine-tenths of the stated quantity of oxygen be supplied. Then only 0.9 pound of carbon can be burned, and the heat evolved is

$$4450 \times 0.9 = 4005$$

B.t.u. The elevation of temperature is then

$$\frac{4005}{(2.097 \times 0.245) + (1.197 \times 3.35 \times 0.244) + (0.1 \times 0.241)} = 2650 \quad (D)$$

degrees, 0.1 pound of carbon having a specific heat of 0.241 being left on the grate. This conclusion may be generalized by noting that the numerator of the fraction is decreased strictly in proportion to the deficiency of oxygen, while the denominator is not decreased in quite so great a proportion, as the one pound of carbon is still there. Consequently the value of the fraction always decreases, lessening the elevation of temperature; but more important than this is the fact that one-tenth of the heat in the fuel, which has been paid for, is not utilized. From both standpoints, therefore, restriction of air supply below the amount theoretically necessary for combustion decreases the evolution of heat, lowers the resulting temperature and results in loss.

If the air supply is in excess of that necessary, loss again occurs, and this loss is evidenced in two ways; first, by the decreased elevation of temperature, owing to the greater amount of gas present absorbing additional heat; and second, by the additional heat wasted at the stack by reason of the temperature of the escaping gases. On the furnace temperature the effect of excess air may be readily ascertained by reference to the computations already made. Thus, in burning carbon to CO_2, if twice as much air be supplied as is necessary for combustion, there will be supplied in addition to the amounts previously estimated for each pound of carbon burned, 2.67 pounds of oxygen and 2.67×3.35 pounds of nitrogen. The elevation of temperature, with a specific heat of 0.218 for oxygen, will then be

$$\frac{14,500}{(3.67 \times 0.2164) + (2.67 \times 3.35 \times 2 \times 0.244) + (2.67 \times 0.218)} = 2530 \quad (E)$$

degrees.

Similarly, for carbon burning to CO, in air exceeding the theoretical amount by 100 per cent., the temperature rise would be:

$$\frac{4450}{(2.33 \times 0.245) + (1.33 \times 3.35 \times 2 \times 0.244) + (1.33 \times 0.218)} = 1470 \quad (F)$$

degrees.

Hydrogen would give, with the same excess of air,

$$\frac{51,486}{(9 \times 0.4805) + (8 \times 3.35 \times 2 \times 0.244 + (8 \times 0.218)} = 3370 \quad (G)$$

degrees.

On the basis that the availability of heat for doing work depends upon its temperature, it is evident that a serious loss of availability follows the introduction of excess air during combustion.

Chemical Composition of Fuel Determines Heating Value

Commercial fuels differ widely in their chemical composition, and the reactions which occur during combustion are far more complex than the simple ones which have been assumed. Besides carbon, hydrogen and oxygen, all coals contain infusible ash, most coals certain traces of sulphur and phosphorus, and in some cases arsenic is found. The last three substances are fuels. The ash detracts from the heating value, since it must be heated up to the temperature of the furnace, and much of this heat afterward rejected.

Considering only the three principal elements in the fuel, it is possible to calculate, though not exactly, the probable heating value of the fuel from its chemical composition. Suppose a fuel to contain 93 per cent. of carbon, 4 per cent. of hydrogen and 3 per cent. of oxygen, no incombustible ash being present. From each pound of fuel the following amounts of heat should apparently be developed:

		B.t.u.
Carbon	$0.93 \times 14,500 =$	13,500
Hydrogen	$0.04 \times 61,800 =$	2,472
Total		15,972

In burning, the hydrogen forms water, and this water absorbs heat, as has been shown, in rising in temperature, evaporating and superheating. Each pound of hydrogen unites with eight pounds of oxygen from the air, but if this oxygen is already contained in the fuel, less oxygen need be supplied by the air. For the case under consideration,

$$8 \times 0.04 = 0.32$$

pound of oxygen is required, of which 0.03 pound is furnished by the fuel itself, leaving 0.29 pound to be furnished by the air. As has been shown, for each pound of hydrogen burned,

$$(966 \times 9) + (9 \times 180) = 10,314$$

B.t.u. must be deducted from the total heating value, representing the heat spent in evaporating the water. For 0.04 pound of hydrogen the deduction is 412.6 B.t.u., or generally speaking, if x is the percentage of hydrogen, the deduction to be made is

$$1146 \times 9x.$$

Deducting in this case 412.6 B.t.u. will leave 15,559.4 B.t.u. as the heating value of the fuel. This, however, is not correct. The hydrogen in the fuel is partly combined with the oxygen in the form of water. This water is driven off at moderate temperatures, and the hydrogen available as fuel is only that portion which is uncombined with oxygen. The 0.03 pound of oxygen in the fuel retains

$$\frac{0.03}{8} = 0.00375$$

pound of hydrogen, and the available hydrogen is only

$$0.04 - 0.00375 = 0.03625$$

pound. Its heating value is

$$0.03625 \times 61,800 = 2230$$

B.t.u., leaving 15,357 B.t.u. as the net heat- the coal 15,730 B.t.u., from which should be deducted

$$10,314 \times 0.03625 = 373$$

B.t.u., leaving 15,357 B.t.u. as the net heating value. The general formula for heating value is then

$$14,500\,C + 61,800\left(H - \frac{O}{8}\right),$$

in which C, H and O are the weights of those elements in one pound of the fuel. This formula, known as Dulong's, is accurate for ordinary coals and fuel oils, but is not applicable to some of the gases used as fuels.

Calculated Heat Values Not Always Accurate

If it were not for the difficulty of accurately determining the elementary composition of fuels, Dulong's formula would afford in many cases a better method of establishing the heating value than the

*This figure is also higher than that of Bunsen's, for the reason already stated.

calorimetric test, but in fuels containing over 15 or 20 per cent. of volatile matter, including all gas fuels, it is generally unreliable. Two gases, like C_2H_2 and C_6H_6, for example, may have the same percentage composition with entirely different heating values. The former gas has a heating value of 21,856 B.t.u. per pound, while the latter has only 18,094 B.t.u. Dulong's formula gives exceptionally close results with fuel oil, however, in which the hydrocarbon or volatile matter exceeds the 15 per cent. limit. It is not closely applicable with rich hydrocarbon fuels, since it does not take account of the heat of combination of the elements in the hydrocarbon compounds. In arriving at the heat of combustion by calulation, the heat of combination must be deducted. This explains why two hydrocarbons having the same percentage elementary composition, may yet differ in heating value. In "The Calorific Power of Fuels," Poole gives the following table showing the difference between the calculated and actual heats of combustion in four cases, expressing the heating values in calories per kilogram:

DIFFERENCE BETWEEN THE CALCULATED AND ACTUAL HEATS OF COMBUSTION

Gases.	Carbon.	Hydrogen.	Calculated Heat	Actual Heat.	Difference.
Marsh gas..... (CH_4)	75.0	25.0	14,685	13,343	+ 1342
Olefiant gas .. ... (C_2H_4)	85.7	14.3	11,859	12,182	— 323
Acetylene..... (C_2H_2)	92.3	7.7	10,114	12,142	— 2028
Benzine ..... (C_6H_6)	92.3	7.7	10,114	12,410	— 2296

In making the calculations for the net heating value of hydrogen the method followed by standard writers has been adopted. This is slightly incorrect when the hydrogen is burned in air, since besides heating the water formed by combustion the nitrogen must also be heated up to 212 degrees before any heat is available for heating the products of combustion above this temperature. The heat used in raising the temperature of the nitrogen is, per pound of hydrogen burned, $8 \times 3.35 \times 0.244 \times (212 - 32) = 1175$ B.t.u. Deducting this, the available heat from the combustion of a pound of nitrogen in just a sufficient amount of air is reduced to 50,311 B.t.u. Furthermore, with 100 per cent. excess air, eight useless pounds of oxygen and 26.8 pounds of nitrogen must be heated, absorbing

$$(8 \times 0.218 \times 180) + (8 \times 3.35 \times 0.244 \times 180) = 1489$$

B.t.u., again reducing the heating value to 48,822 B.t.u. Equations (C) and (G) may, therefore, be modified by placing these new values in the numerators, which will give for the theoretical air supply.

$$\frac{50,311}{(9 \times 0.4805) + (8 \times 3.35 \times 0.244)} = 4640 \quad (J)$$

degrees, and for 100 per cent. of excess air.

$$\frac{48,822}{(9 \times 0.4805) + (8 \times 3.35 \times 2 \times 0.244) + (8 \times 0.218)} = 2560 \quad (K)$$

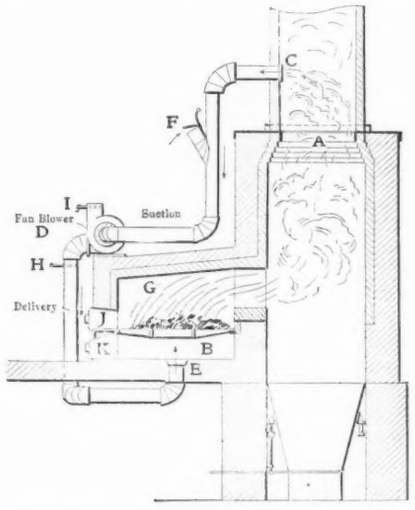
degrees. These are temperature elevations measured above 212 degrees.

Furnace Temperatures

In actual combustion the temperatures attained are always less than the maximum above given, owing to either a deficient or an excess supply of air. At high efficiency, with the air supply just right, this temperature would be quite destructive. Even the temperatures attained in boiler-furnace operation are found to bring about rapid deterioration. So far as the furnace alone is concerned, a lower temperature would be better if it could be obtained without such modification in conditions as would be detrimental to the efficiency. Unfortunately, however, any modifications of temperature brought about by either excessive or deficient air supply, results in loss. With a deficient supply of air the fuel is incompletely consumed, and does not evolve its full heating value, while with too much air a larger bulk of products of combustion is produced, resulting not only in decreased temperature of combustion, but in a serious loss. Some of the heat of combustion must in all cases be wasted. At some temperature, always higher than that at which air was brought to the fuel, the heat ceases to be available for doing work and must be rejected. In the case of the steam boiler, this heat is discharged to the stack, say, at a temperature of 500 degrees. The amount of heat thus rejected depends simply upon the temperature and the quantity of gases. If the quantity of air is increased in order to lower the furnace temperature, the amount of heat eventually rejected is correspondingly increased, decreasing the efficiency of the process of which combustion is a part.

If the terrestrial atmosphere contained less oxygen, more air would have to be supplied to burn fuel, the temperature of combustion would be lower and the heat rejected greater; if more oxygen, less air would be supplied and the temperature of combustion would be inconveniently high. If the heating value of ordinary fuel were less than it is, furnace temperatures would be less, and with atmospheric air the heat rejected would be the same as it now is. The heating values of fuels vary quite widely, but there is no tendency evident toward the use of the lower-grade fuels in preference to the others, excepting as brought about by the element of cost. The inconvenience of high furnace temperatures is more than offset by operative and financial considerations.

If there were any way to decrease furnace temperature without increasing heat rejection, such a practice might be applicable to many industrial operations involving the use of fuel. In order to accomplish the apparently incompatible results, it is only necessary that any excess of the medium of combustion, for example, air, should be brought to the fuel at the same temperature as that at which heat is rejected to the chimney. Suppose the medium of combustion to be a portion of the chimney gases. Then, so long as a sufficient quantity of air is supplied with it to permit of complete combustion of the fuel, the temperature of combustion may almost indefinitely be lowered by increasing the proportion of chimney gases. No increase



REDUCING TEMPERATURE OF COMBUSTION WITH WASTE GASES

of heat rejection occurs, excepting the slight amount of heat that might be lost by radiation, etc., as the gases pass from the chimney back to the fire.

Adjustment of Air Supply

A device for accomplishing this very result is shown in the accompanying illustration.* In this illustration G is a grate on which fuel is burned, the products of combustion passing to the stack A. An outlet C from this stack communicates with the blower D, which may also draw air through F. The mixed air and gases are discharged through the gate D into the closed ash-pit B. It is easy to see that almost any desired temperature may be attained without increasing the loss of heat from the top of the stack.

Suppose the fuel to be carbon, and that an elevation of temperature of 600 degrees

*From "Flame Regulation in Chemical and Metallurgical Operations," by Carleton Ellis, in *Electrochemical and Metallurgical Industry*, December, 1904.

is desired. Taking the specific heats of the air and gases at 0.23 for simplicity, we have

$$0.23\ (x + 1)\ (t_1 - t_0) = 14{,}500$$

or

$$0.23\ (x + 1)\ (600) = 14.500,$$

in which $(t_1 - t_0)$ is the temperature elevation of 600 degrees. Then x, the amount of air and gases to be supplied per pound of fuel, is 104 pounds. If this amount of pure air were supplied, and the difference in temperature between the escaping products of combustion and the inlet air were 400 degrees, then

$$104 \times 400 \times 0.23 = 9568$$

B.t.u. would be wasted per pound of fuel burned. If 90 pounds of waste gases were supplied with 14 pounds of pure air, the waste of heat would be only

$$14 \times 400 \times 0.23 = 1288$$

B.t.u., since the waste gases would come back to the fire at practically the same temperature as that at which they were discharged. The loss of heat to the stack would, therefore, be reduced by about 86½ per cent., and would be substantially the same as that which would have been experienced if 14 pounds of pure air without any admixture of waste gases had been used for the combustion of each pound of fuel. The only difference would be in the greatly reduced furnace temperature accomplished, so far as the furnace is concerned, without loss of heat. In practice the escape of any gas through *I* in the illustration would not affect the operation.

Practical operation of this principle has been secured in applications to cement kilns and lime burning, in which a control of temperature is essential.* In other industrial operations the advantage of comparatively low furnace temperatures without loss of heat may extend its applications. In that class of operations of which steam generation is typical, a serious objection arises. Heat cannot be transferred from a body to another body at a higher temperature than itself. A steam boiler operating at ordinary pressures is at a temperature of from 320 to 370 degrees. It can only absorb heat from gases at a higher temperature than itself. If carbon is burned under a steam boiler, which has a temperature of 370 degrees and utilizes 25 pounds of air at 50 degrees per pound of fuel, that part of the heat of combustion which is exerted in raising the temperature of the gases to 370 degrees, approximately

$$26 \times (370 - 50) \times 0.23 = 1914$$

B.t.u., or 13.2 per cent. of the total heat in the fuel, cannot possibly be absorbed. Under these conditions the boiler efficiency cannot exceed 86.8 per cent., and usually the efficiency would be less, since in very few boilers do the gases reach the flue at a temperature as low as that of the boilers themselves.

According to the theory advanced by Professor Perry, the efficiency of heat absorption of a steam boiler is independent of the initial temperature of the gases. That is to say, if a boiler absorbs 70 per cent. of the heat in the gases when at an initial temperature of 2000 degrees, it will still absorb 70 per cent. if the initial temperature is only 1000 degrees. The uniform loss of 30 per cent. means that the final temperature, that of discharge to the stack, based on the initial temperature of the air as zero) must be inversely proportional to the amount of gas produced by combustion, and since the initial temperature of combustion is also inversely proportional to this amount of gas, the initial temperatures and stack discharge temperatures must be directly proportional to each other. Consequently, the heat-absorbing capacity of the boiler is practically unlimited. This is such a startling contradiction of existing ideas on the subject that further consideration is warranted.

Ordinarily, the rate of transmission of heat is supposed to be proportional, in some way, to the difference of temperature. Professor Perry concedes this point, but goes on to show that on this basis an ordinary boiler is called upon to transmit to the water only about 0.001 as much heat as it might. Other factors may, therefore, serve to modify the rate of transmission in actual practice. Some of these factors are the number of molecules per cubic inch of gas, the specific heat of the gas, and the velocity of the gas. As the temperature of the gas increases, the decrease in the number of molecules diminishes the convection of heat, and consequently tends to offset the effect of the high temperature. The effect of any decrease in the specific heat at high temperatures is also to decrease the rate of convection. As to the velocity of the gas, Professor Perry assumes that at low velocities corresponding to low amounts of gas and high furnace temperatures, an inert film of gas adheres to the heating surface; at high velocities this film is scraped off and the transmission is more rapid. The three factors, then, so far as we have accurate knowledge of them, must tend to overcome the increase in rapidity of heat transmission which should follow increased temperature of the gas.

Recent tests by the United States Geological Survey have shown that when the temperature of combustion is maintained constant, the exit temperature of the gas remains constant, regardless of the velocity of the gases through the boiler.† The heat-absorbing power of the boiler is, therefore, not affected by any variation in the quantity of gas within the limits of practice. Practically, the heat-absorbing power may be regarded, as by Professor Perry, to be unlimited.

That portion of the heat of combustion which is transferred to a boiler by radiation, depends on the temperature and specific heat alone. Since by the law of Stephan and Boltzmann the transfer by radiation is proportional to the difference of the fourth powers of the temperatures, the heat radiated in boiler operation doubles for about 500 degrees increase of furnace temperature.‡ The experiments made by the Geological Survey indicate, however, that only a part of the total transfer of heat is effected by radiation, varying from perhaps 50 per cent. in horizontal tubular boilers down to possibly 20 per cent. in water-tube boilers. To this extent high furnace temperatures increase the heat-absorbing power of the boiler, and this increase may or may not be counterbalanced by the other factors affecting the transfer of heat by conduction and convection.

Further tests by the Geological Survey are summarized in a paper by W. T. Ray and Henry Kreisinger,** as follows:

1. After the velocity of the gas parallel to the heating surface has reached a certain point, the rate of heat absorption is almost proportional to the velocity.

2. The rate of heat absorption increases when the initial temperature rises; it also seems to vary directly with the density of the gas.

3. Increasing the diameter of the flues decreases their absorbing power. Increasing their length beyond a certain point increases the efficiency very little.

On this subject the various data can only be summed up by concluding that lessened furnace temperatures would tend toward a lower boiler economy. The far more important deduction is, that much higher rates of combustion than are generally practiced are possible without loss of evaporative efficiency. Since high rates of combustion generally lead to high furnace efficiency, their use must, therefore, inevitably lead to increased economy of the boiler as a whole. In this there is nothing new, since engineers have been advocating higher rates of combustion for at least five years past.

As to high furnace temperature, the condition which produces this result is that of proper air supply; and since this condition also leads to minimum loss at the stack, adjustment of air supply is the overwhelming factor in economical combustion and steam generation.

It is stated that about 25,000 incandescent electric lights are in use in the new Singer building in New York.

*In the large class of operations of which these two are typical, a long flame is necessary. This leads to the use of rich hydrocarbon fuels. On account of operative difficulties soft coal cannot be employed so that natural gas, fuel oil, or pulverized coal are alone available. The first is scarce, the second expensive. Pulverized coal is the only solution of the difficulty (and this must be made from a highly volatile soft coal) unless flame lengths can be artificially increased by a reduction of furnace temperatures.

†Walter C. Finlay (*Trans.* A. I. E. E., Dec., 1907) also reports an increase of 70 per cent. in the rate of evaporation without decrease of efficiency, showing that, up to this point, the increase in flue-gas temperature is not greater than the increase in fuel consumption.

‡*Engineering*, Nov. 1, 1907, p. 601.

**Western Society of Engineers, Sept. 18, 1907.

Troubles with Steam Turbine Auxiliaries

By Walter B. Gump

The case about to be described concerns a steam plant in which there were seven cross-compound condensing Corliss engines, and two Curtis steam turbines. The latter were each of 1500-kilowatt capacity, and were connected to surface condensers, dry-vacuum pumps, centrifugal, hot-well and circulating pumps, respectively. In the illustration the original lay-out of piping is shown in full lines. Being originally a reciprocating plant it was difficult to make the allotted space for the turbines suitable for their proper installation. The trouble which followed was a perfectly natural result of the failure to meet the requirements of a turbine plant, and the description herein given is but one example of a great many where the executive head of a concern insists upon controlling the situation without regard to engineering advice or common sense.

Circulating Pump Fails to Meet Guarantee

Observing the plan view, it will be seen that the condensers for both turbines receive their supply of cooling water from the same supply pipe; that is, the pipes, both suction and discharge, leading to No. 1 condenser are simply branches from No. 2, which was installed first without consideration for a second unit. When No. 1 was installed there was a row of columns from the basement floor to the main floor extending in a plane which came directly in front of the condenser. The column *P* shown in the plan was so located as to prevent a direct connection between the centrifugal circulating pump and the condenser inlet. The centrifugal pump was direct-connected to a vertical high-speed engine, and the coupling is shown at *E* in the elevation.

Every possible plan was contemplated to accommodate the engine and pump without removing any of the columns, and the arrangement shown was finally adopted, leaving the column *P* in its former place by employing an S-connection from the pump to the condenser. It should be stated that the pump was purchased under a guarantee to deliver 6000 gallons per minute under a head of 50 feet, with an impeller velocity of 285 revolutions per minute. The vertical engine to which the pump was connected proved to be utterly unfit for running at a speed beyond 225 to 230 revolutions per minute, and in addition the S-bend would obviously reduce the capacity, even at the proper speed of the impeller.

Besides these factors there was another feature even more serious. It was found that when No. 2 unit was operating, No. 1 could not get as great a quantity of circulating water as when No. 2 was shut down. This was because No. 2 was drawing most of the water, and No. 1 received only that which No. 2 could not pull from the suction pipe *A*. This will be clear from the fact that the suction and discharge pipes for No. 1 were only 16 inches, while those of No. 2 were 20 inches and 16 inches, respectively. The condenser for No. 2 had 1000 square feet less cooling surface than No. 1, which had 6000 square feet and was supplied with cooling water by means of two centrifugal pumps of smaller capacity than for No. 1 and arranged in parallel. These were each driven by an electric motor, and were termed "The Siamese Twins," due to the way in which they were connected.

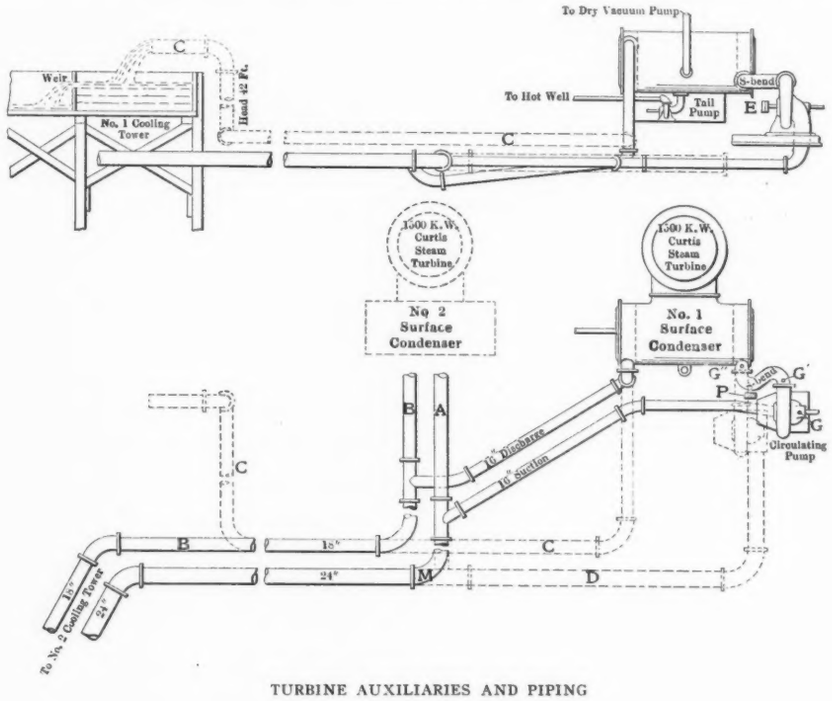
The load factor of the plant ranged from 0.22 to 0.30, the load being almost entirely lighting, so that for the winter season the load factor reached the latter figure. The day load was, therefore, light and not sufficient to give one turbine more than from one-fourth to one-third its rated capacity. Under these conditions No. 1 unit was able to operate much more satisfactorily than when fully loaded, because of the fact that the cooling water was more effective. This was, of course, all used by No. 1 unit when No. 2 was not operating. At best, however, it was found that the vacuum could not be made to exceed 24 inches, and during the peak, with the two turbines running, the vacuum would often drop to 12 inches. A vacuum of 16 inches or 18 inches on the peak was considered good.

An Investigation

Severe criticism "rained" heavily upon the engineer in charge, and complaints were made in reference to the high oil consumption. An investigation on the company's part followed, and the firm which furnished the centrifugal pump and engine was next in order to receive complaints. Repeated efforts were made to increase the speed of the vertical engine to 285 revolutions per minute, but such a speed proved detrimental to the engine, and a lower speed of about 225 revolutions per minute had to be adopted.

A thorough test on the pump to ascertain its delivery at various speeds was the next move, and a notched weir, such as is shown in the elevation, was employed. The test was made on No. 2 cooling tower, not shown in the sketch, and showed that barely 3000 gallons per minute were being delivered to the cooling tower. While the firm furnishing the pump was willing to concede that the pump might not be doing all it should, attention was called to the fact that there might be some other conditions in connection with the system which were responsible for the losses. Notable among these was the hydraulic friction, and when this feature of the case was presented, the company did not seem at all anxious to investigate the matter further; obviously on account of facing a possible necessity for new piping or other apparatus which might cost something.

Approximately 34 feet was the static head of water to be pumped over No. 2 cooling tower. Pressure gages were connected to the suction, discharge, and condenser inlet, as shown at *G*, *G'* and *G"* respectively. When No. 1 unit was operating alone the gage *G* showed practically zero, indicating no vacuum in the suction pipe. Observing the same gage when No. 2 unit was running, a vacuum as high as



TURBINE AUXILIARIES AND PIPING

2 pounds was indicated, showing that No. 2 was drawing more than its share of cooling water from the main A and hence the circulating pump for No. 1 was fighting for all it received. Gage G' indicated a pressure of 21 pounds, while G'' indicated 18.5 pounds, showing a difference of 2.5 pounds pressure lost in the S-bend. This is equivalent to a loss of head of nearly 6 feet, 0.43 pound per foot head being the constant employed. The total head against which the pump worked was therefore

$$G' + G = 21 + 2,$$

or

$$\frac{23}{0.43} = 53$$

feet, approximately. Since the static head was 34 feet, the head lost in friction was evidently

$$53 - 34 = 19$$

feet, or

$$\frac{1900}{53} = 36$$

per cent., approximately.

Supply of Cooling Water Limited

In addition to this the supply of cooling water was limited, the vacuum being extremely low at just the time when efficient operation should be had. The natural result occurred, which was this: As the load on the turbine increased, the amount of steam issuing into the condenser increased, heating the circulating water to a temperature which the cooling tower (not in the best condition) was unable to decrease to any great extent. The vacuum gradually dropped off, which indicated that the condenser was being filled with vapor, and in a short time the small centrifugal tail-pump lost its prime, becoming "vapor bound," and the vacuum further decreased. The steam which had condensed would not go into the tail-pump because of the tendency of the dry-pump to maintain a vacuum. When a certain point was reached the dry-vacuum pump started to draw water in its cylinder, and the unit had to be shut down immediately.

Vapor-bound Pumps

As the circulating water gradually rose in temperature the circulating pump also became "vapor bound," so that the unit would be tied up for the rest of the night, as this pump could not be made to draw hot water. The reason for this condition may be explained in the following way. When the circulating pump was operating and there was a suction of 2 pounds indicated at G, the water was not flowing to the pump of its own accord, but was being pulled through by force. This water would flow through the pump until a point was reached when the water became hot enough to be converted into vapor, this occurring at a point where the pressure was sufficiently reduced to cause the water to boil. Naturally this point was in the suction pipe and vapor was thus maintained behind the pump as long as it was operating. In this case the pump was merely maintaining a partial vacuum, but not drawing water. After the vacuum was once lost, by reason of the facts given, it could not be regained, as the circulating water, piping and condenser required a considerable period of time in which to cool.

Before any radical changes were made it was decided that a man should crawl in the suction pipe A and remove such sand, dirt or any other obstacles as were believed to cause the friction. After this had been done and considerable sand had been removed, tests were resumed with practically the same results as before. The investigation was continued and the dry-vacuum pumps were overhauled, as they had been damaged by water in the cylinders, and furthermore needed reboring. In short, the auxiliaries were restored to the best condition that could be brought about by the individual improvement of each piece of apparatus. As this was not the seat of the trouble, however, the remedy failed to effect a "cure." It was demonstrated that the steam consumption of the turbines was greatly increased due to priming of the boilers, as well as condensation in the turbine casing; hence, the ills above mentioned were aggravated.

Changes in Piping

After a great deal of argument from the chief engineer and the firm which furnished the pump, both making a strong plea for a change in the piping, the company accepted the inevitable, and the dotted portion shows the present lay-out. The elbow M was removed, and a tee put in its place to which the piping D was connected. The circulating pump was removed to the position shown, and a direct connection substituted for the S-bend. The discharge pipe C was carried from No. 1 unit separately, as shown in the elevation, and terminated at No. 1 cooling tower instead of No. 2, which shortened the distance about 60 feet, the total length of pipe (one way) from No. 1 unit being originally about 250 feet. In this way the condensing equipment was made practically separate for each turbine, as it should have been in the first place.

With the new piping a vacuum of 24 inches on the peak could be reached. While this is far from an efficient value, yet it is better than the former figure. The failure to reach a vacuum of 28 inches or better is due primarily to a lack of cooling water, but an improvement in this regard could be made by reconstructing the cooling towers, which at present do not offer the proper amount of cooling surface. The screens used were heavy galvanized wire of about 3/16-inch mesh, which became coated in a short time, and must be thoroughly cleaned to permit the water to drop through them. The supply of cooling water was taken from a 30-inch pipe line several miles long and fed from a spring. The amount of water varied considerably and was at times quite insufficient for the load on the plant. Instead of meeting this condition with the best apparatus possible, a chain of difficulties were added to it, with the results given.

Locating Defects in Steam Pumps

By W. H. Wakeman

It is both interesting and instructive to watch the operation of a steam pump when its irregular movements show that it is not in good order, and from these observations endeavor to locate the cause of trouble. When the pump is taken apart

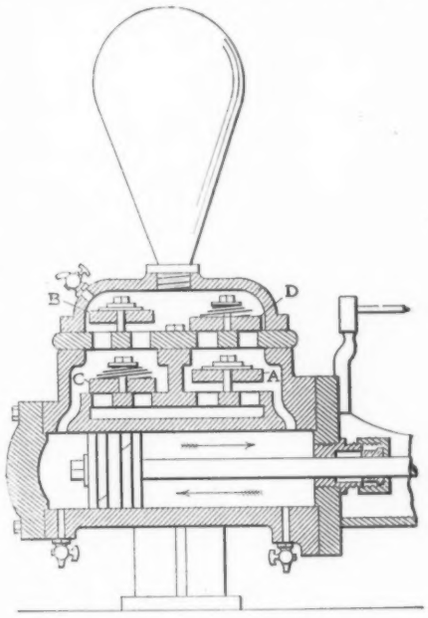


FIG. 1. SECTION THROUGH WATER END OF PUMP

to be repaired, care should be taken to see if the assumed cause of imperfect working agrees with the real cause, and if it does not, then a reason for the difference ought to be found and the circumstances carefully noted for future reference. If engineers would always do this in an intelligent manner, their knowledge of pumps of all kinds would be much more satisfactory to themselves and their employers than it is in some cases.

The last time that the writer's attention was called to this matter was when one of his pumps began to show signs of failure. This pump is clearly shown in the sectional view, Fig. 1, with two of the water valves open and two closed. When a stroke was made in the direction indicated by the lower arrow, the piston moved steadily through the whole stroke, and during this time the suction valve A and the discharge valve B were open for the circulation of water.

This action gives no indication of the condition of these valves, for if they were badly worn, or removed altogether, the piston would move steadily forward because the water passages are open. In case one or both were fastened down so that they could not be opened, the piston

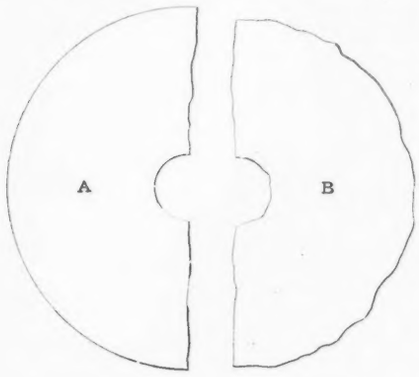


FIG. 2. HALF VIEWS OF PUMP VALVES

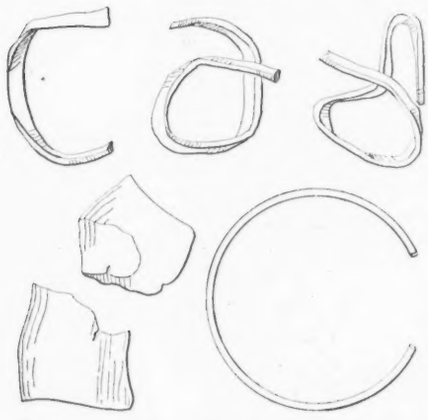


FIG. 3. BROKEN PARTS FROM WATER CYLINDER

would show it, but this defect is seldom found in a pump.

The piston's action when moving in the direction indicated by the lower arrow shows that the suction valve *C* is tight, for if it were not, water would be forced back through it into the suction pipe. It also shows that the discharge valve *D* is in good order, for if it were not, water would be forced through it into the suction passage underneath, and as either of these defects would affect the piston, they could easily be traced.

When the piston moved in the direction indicated by the upper arrow, with the valves *C* and *D* opened and *A* and *B* closed, it quickly traversed the stroke, and for this reason showed plainly that it did little or no work. It was concluded that this action was due to a defective suction valve at *A* which allowed water to return to the suction pipe instead of going to the boiler, or was caused by a broken or worn-out discharge valve at *B* allowing water to rush down back of the piston into the cylinder. It was impossible to decide in advance which of these valves was defective, but when the pump was taken apart, *A* was found in good order, as shown in Fig. 2, but *B* was badly worn.

The action just described seldom or never indicates a leaky piston, for in that case the piston would move alike on both strokes. As with a leaky piston the slip is excessive, it becomes necessary to run the pump faster to get the usual amount of water, and the speed must be increased more and more in proportion to the amount of leakage.

Curing a Leak

For more than a dozen years the pump referred to has been in service and has been used for cold water only. The valve seats were not in perfect order, but the soft-rubber valves adapted themselves to the rough seats and prevented leakage. However, when I wished to replace *B*, also *D*, which was badly worn but did not leak, there were no soft-rubber valves in reserve, but plenty of hard-rubber valves for use in hot-water pumping. These alone were useless, because they would permit water to leak through so rapidly that none would go to the boilers. However, by putting a piece of pure-rubber packing ⅛ inch thick under each of them, they were made perfectly tight. Of course the packing was cut in circular form to correspond to the valves, and was only used until suitable soft-rubber valves could be procured.

In another case a single pump that was used to feed a pair of boilers would always pound badly except when running at a very slow speed. The main steam valve of this pump was of the common D-slide-valve type, and by having a new valve cast with about ¼ inch more inside lap, the steam piston received the benefit of more compression and the pound was greatly reduced.

Fig. 3 illustrates the broken parts that were found in one of the water cylinders of a duplex hot-water pump. When new, these parts held the rings of fibrous packing in place, but due to long and continued neglect they became loose, fell out and were crushed out of shape by the moving piston. When steam was admitted to the cylinder on the same side of the pump, the piston would jump from one end to the other of each stroke, thus indicating that the water piston was out of order. It could not deliver water in this condition, but was continued in service because the other water piston was in fair working order and by running the pump fast the boiler was supplied with water. Finally the follower-plate dropped off from the piston-rod, and as it was too stiff to be crushed by the piston, the next stroke could not be completed.

As the pump was now wholly disabled, it became necessary to use other means for supplying the boiler. This pump took hot water from a receiver into which drips from a heating system discharged in the usual way, and cold water from a street main supplied the extra quantity usually required in such cases. The cold water was shut off and the hot water was allowed to run into the sewer.

For use in such an emergency the plant was equipped with a good injector, but when an attempt was made to use it to force water into the boiler the result was a failure. Some loose scale found in the steam space accounted for its failure to work properly. The engineer finally succeeded in starting a spare pump and the plant was not shut down for lack of water, but it was a narrow escape.

A Home-made Pump Regulator

By R. O. Richards

A "home-made" contrivance was a pump regulator shown in the accompanying sketches, and though the writer is aware of glaring faults in its construction, it worked well; in fact, better than some regulators on the market. The column *A*, Fig. 1, was originally of the float-and-whistle type. The whistle was removed, and a piece of smoothly bored 1-inch pipe

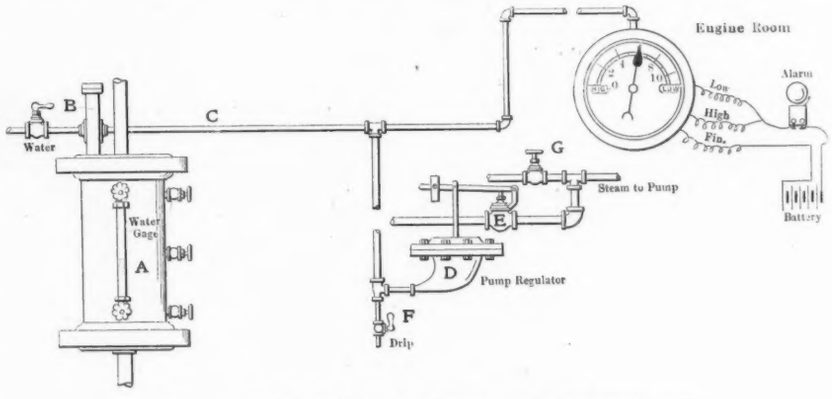


FIG. 1. CONNECTIONS OF A HOME-MADE PUMP REGULATOR

inserted in its place. A ½-inch water pipe *C* was tapped to it by means of thimbles. A balanced piston is attached to the float lever. When the float descends, the piston rises, allowing the water to escape around the opening *EE*, Fig. 2, thus creating more or less pressure under the 2-inch

diaphragm *D* which in turn controls the opening and closing of the quick-opening valve *E*, which is placed on an auxiliary steam supply to the feed-pump.

The drip *F* must, of course, be more or less open, so as to allow the pressure under *D* to accumulate gradually. In practice, the valve *G* is opened enough to work the pump at a slow speed, not quite fast enough to supply the required feed-water, so that some steam must be supplied through the valve *E*, and this supply is governed by the regulator. The water in the pipe *C* is under 10 pounds pressure, being supplied from a plumber's float-tank, not shown. When there is a clear opening through the cylinder *B*, full 10 pounds pressure is maintained in the pipe *C*; but when shut off the pressure is *nil*. Piping a light gage in this water pipe, then, would show the water pressure in this pipe, and consequently the level of the water, to a certain extent. This gage was placed in the engine room, and an alarm wired to it.

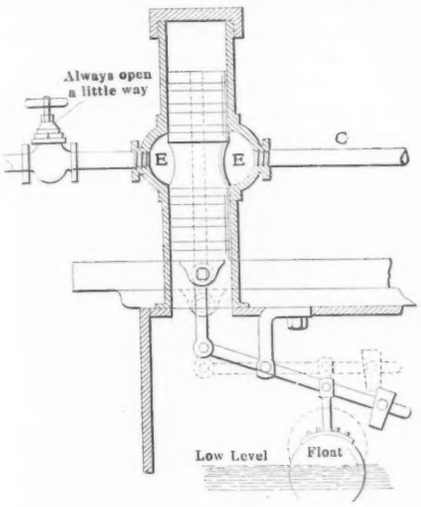


FIG. 2

Experience of a Trouble Man

By R. A. Walkway

Robert Billings, called "Bob" for short, was employed as a trouble man by the All Work-No Play Engine and Machine Company, located in a thriving city not more than twenty miles from Boston.

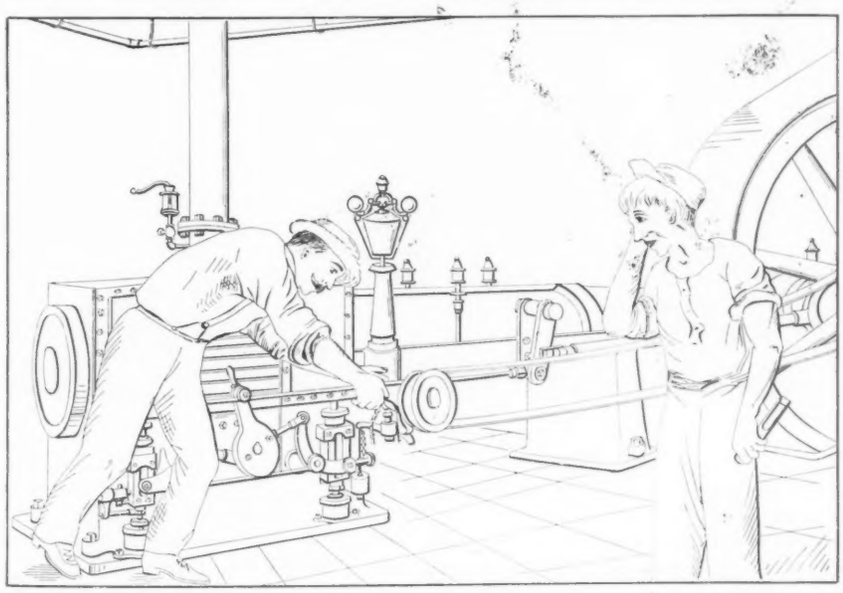
When there were not sufficient troubles to keep "Bob" on the go, he usually had no difficulty in finding something to do in the shop. One day as "Bob" had just completed a rush job, the superintendent told him to go over to Black's place and see what the trouble was with their engine.

"What's the matter with them, anyhow?" grumbled "Bob." "That engine is only two years old and they are having more trouble than as if it were twenty."

"I don't know. They just 'phoned in and wanted a man to come over and get things going. They say the engine won't run and the engineer don't know what to do."

"I should think it would pay those people to get an engineer who knew enough to keep an engine running without shutting the whole plant down. The most of my jobs are caused by the engineers trying to make changes and not studying out beforehand what the result will be. It's a good deal like getting married in a hurry and then spending your time wondering how it happened." So saying, "Bob," after packing his tool grip, started for Black's engine room.

Arriving there, he made his way to the office and after stating his business was shown the way to the engine room.



"YOU HAVE NEGLECTED TO PULL THIS PIECE OF WASTE OUT OF THE GOVERNOR GEARS"

"Now," said "Bob," turning to the bewildered looking engineer, "what was you doing and how was the engine working just before it stopped?"

"Why the engin' was pumpin' 'long fine like, and I wasn't doin' nothin' 'cept wipin' the dirt and oil off the frame. I didn't do a thing to the engine. No, sir, I didn't!"

"Oh you was just wiping off the engine, was you? Well, where was you wiping the engine, about by the governor gears?"

"Yep! I was standin' right in front of 'em when the engin' stopped, and there was plenty of steam, too, for the gages showed 100 pounds of steam on um."

"Of course there was plenty of steam. It is very fortunate that you let your safety cams alone and they operated. The only trouble I can see with your engine is that you have neglected to pull this piece of waste out of the governor gears which got in when you were wiping the engine frame," and as "Bob" said this he pulled a piece of waste from between the gear teeth.

The safety catch was then thrown up to hold the safety knock-off cams away far enough from the catch-block arm so that the block would catch on and lift the valve. The throttle was then opened and the engine started up the same as usual.

"Well, I'll be jiggered!" exclaimed the engineer, who had watched the removing of the waste with interest, "I never had an idea—"

"I shouldn't think you had," interrupted "Bob," "from your present exhibition of mental ability. If you had, you would probably have a better job. I'd hunt my plant over from top to bottom for a trouble before I would send for an outsider; but you ain't the only one." And "Bob," having eased his mind, related the following while holding down the engineer's chair:

"I have some of the simplest things to fix," said he. "One plant I was called on to start up was where they had a new engineer. The equipment was a good-sized slide-valve engine with one of these safety arrangements on the governor belt. The old engineer had never seen the thing work, and so the last thing he did before he left the job for another, when shutting down for the night, was to run the governor belt off and permit the device to close the governor valve. The packing around the governor stem had become hard and when the valve seated the unworn portion of the stem was forced into this hard, unyielding packing and held there.

"When the new engineer came to start up the next morning, the engine refused to move, and as the governor belt was in place and the engine seemed to be all right, he didn't know what the trouble was, or what to do. After he had looked over all the valves and had examined the engine several times, he sent for me."

"How did you know where to look?" grunted the engineer.

"Well," replied "Bob," I had had several experiences of a similar nature before, and as soon as the engineer told me

what had been done the night before, I had a pretty good idea that the trouble would be found with the governor spindle, and it was. All that was done at that time was to lift the spindle and start the engine, but that night it was repacked."

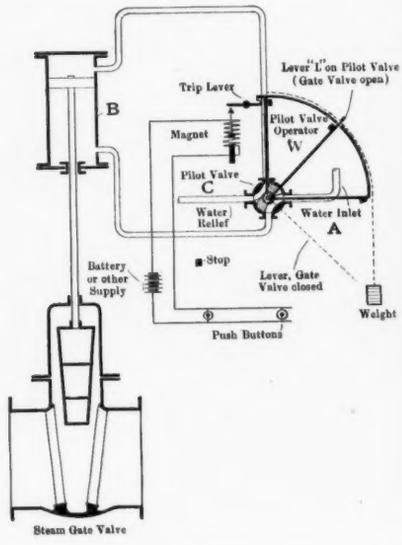
"Humph! That was easy. It's a wonder he didn't think of that before he called for help," remarked the engineer, who had regained confidence in himself.

"Yes, it is a wonder that such simple things can't be found out by the one most interested," replied "Bob," as he lit his pipe and started to go. "There are funny things in this world, as well as funny people, and some don't know when they are knocking themselves."

Remote Controlled Valves in the New York Central R. R. Power Stations

The remote-control system described herein has been developed for the special purpose of closing from remote points high-pressure gate valves in the steam mains of the two turbine-generator power stations of the New York Central & Hudson River Railroad Company.

The arrangement consists of a 14-inch gate valve, actuated by a hydraulic cylinder, of standard construction available on the market. The gate valve is operated by a four-way pilot valve, admitting water supplied either from the city water mains or from the boiler feed-pumps, above or below the hydraulic piston.



ELECTRICAL TRIPPING ARRANGEMENT FOR HYDRAULICALLY OPERATED VALVE

As shown in the illustration, water enters at *A*, moving the piston in the hydraulic cylinder *B* up or down, according to the position of the four-way pilot valve. To the pilot valve is connected a lever *L*, which is turned 90 degrees by the pilot valve operator *W*, when the latter is released by the tripping magnet in case contact is made by a push-button. Current can be obtained from a storage battery, or from any lighting circuit.

It will be noted from the sketch that lost motion is allowed between moving parts in order safely to overcome friction that might otherwise cause sticking of the tripping device or pilot valve. The entire construction is inclosed in a tight cast-iron case, and an indicator shows whether the valve is open or closed. The valve, after it has been tripped, can be re-set by a removable handle.

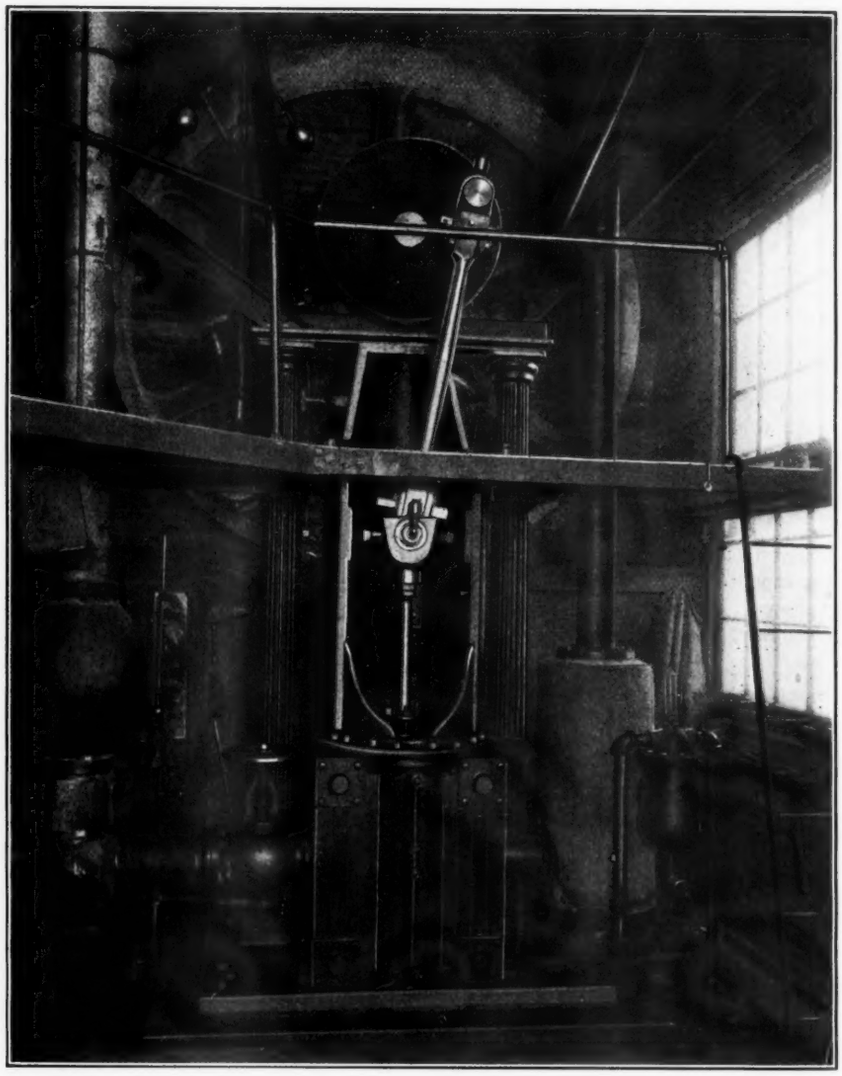


FIG. I. OLD-TIME VERTICAL CORLISS ENGINE

The advantages of this construction are the following:

The valve can be closed from any point in the power station; for instance, from the switchboard gallery. It can either be used to shut off the steam supply from the engines or turbines in case of emergency, or regularly as soon as the electric load is taken off and the machine is to be shut down.

The valve cannot be opened accidentally because the counterweight has to be re-set, making it necessary for a man to go to the valve for opening it. The valve can, however, be opened as readily as any ordinary valve, hydraulically operated, not equipped with the special electrical tripping device.

The time of closing the valve can be adjusted by properly limiting the water supply, making its performance independent from the operator, and permitting the valve to be closed sufficiently slow to avoid excessive strain on the piping.

The mechanism is simple and positive, and it is not apt to get out of order, an advantage over most motor-operated valves. Long and cumbersome water connections are not required as in case of exclusively hydraulic operation.

It should be mentioned that all wiring must be installed most carefully, in order to preclude a possibility of accidentally tripping a valve, or failure to operate in case of emergency. With such a device in the hands of a switchboard operator, giving him control of the steam supply to the engine, it is believed that the safety of operating large power stations can be increased.

There should be no hesitancy to give the

switchboard operator control over the valves in the steam mains to steam-driven generators, for the reason that the steam supply can be shut off as soon as the generator is taken off the system. In case of emergency, for instance, a burn-out of a generator, the main circuit-breaker will trip automatically, and under these conditions the possibility of shutting off the steam supply from the switchboard gallery will tend to decrease the accident and danger to the operating force; also, it will avoid confusion in the engine room.

An Odd Type of Corliss Engine

A peculiar type of Corliss engine, the age of which is not known, is shown here-

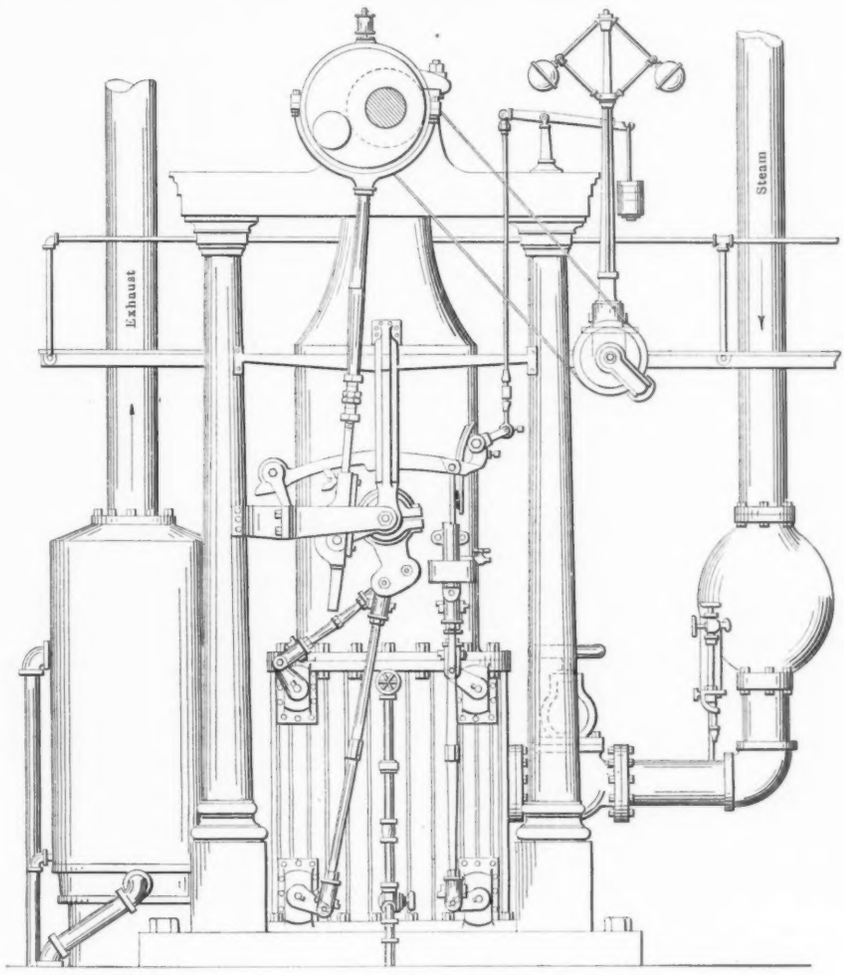


FIG. 2. SHOWING ARRANGEMENT OF THE VALVE-GEAR

with. Fig. 1 shows that the frame rests upon the cylinder, the bottom end of which is bolted to the bed-plate. The main pillow-block is supported above the cylinder by means of the engine frame and the two pillars shown on either side. The outboard bearing is anchored in the brick wall shown behind the engine. The top head of the cylinder is removable, which permits of examining the interior of the cylinder. The guide is of the ordinary type, while the crosshead is fitted with adjusting nuts and bolts.

The valve arrangement is shown in Fig. 2. Here it will be seen that the governor is supported by one of the outer columns and driven by a belt from the crank-shaft. The eccentric-rod operates a wrist-plate, which in turn operates two arms (only one of which is shown) which operates the two steam valves shown top and bottom of the right-hand side of the cylinder.

The cut-off is obtained by the governor-rod operating the knock-off cam, which forces the upper end in and the lower end of the claw containing the catch-block out, thus disengaging the valve-stem and permitting the dash-pot to close the valve. The knock-off arrangement does not move with the arms which are pivoted at the left-hand end, but is attached to the frame of the engine.

The exhaust valves are operated by the adjustable rod from the rocker-arm, as in the ordinary type of Corliss engine. Steam is admitted through the steam pipe shown at the left of Fig. 1 and right of Fig. 2, while the exhaust escapes through the opposite pipes. A railing and walkway are arranged conveniently for the engineer to examine the upper part of the engine.

The steam pipe is fitted with a separator, while the feed-pipe shown by the heater, which is bolted to the engine bed, is equipped with a filter, shown suspended between the two vertical feed-pipes, Fig. 1.

The age of this engine is unknown. The first information that can be obtained regarding it is that it was purchased about 35 years ago by Rupert W. Peck, owner of the City Machine Company, Providence, R. I. The engine proving too large, was sold to Frank McSwegan & Son, dealers in second-hand engines and boilers, 3 Dover street and Franklin square, New York City. The engine was next sold to the Catskill Paper Company, and about 1885 to the Allen Rope Works Company, Brooklyn, N. Y., where it was operated for about eight years, when the works were abandoned and the engine allowed to lie idle for ten years, during which time the brasses, oil cup and valve-gear were stripped by boys or tramps and probably sold for old junk.

The engine was fitted up anew in 1902 and sold to the Bowne Milling Company, Brooklyn, N. Y., where it may be now seen in operation. So far as known there is only one other engine of this type in operation at the present time. The engine operates very smoothly and according to the engineer's report is very economical.

Air in Feed Water

By Peter Van Brock

Air is a mixture of oxygen and nitrogen, which last is simply to dilute (weaken) the oxygen, or we should burn up in an hour, by breathing pure oxygen.

Water is a chemical combination of oxygen and hydrogen, and these two are practically inseparable, in the form we drink or boil or drown in.

In air the oxygen is at liberty to burn slowly. We call it rusting, or as some may call it, "pitting." But all water contains air, which can only be compelled to leave the water by boiling it, in an open vessel, at 212 degrees, or somewhere near it. And as air expands more quickly than water, the air bubbles promptly rise out of the water into their own place, the atmosphere.

Thus, if the lower part of this vessel be connected to the receiver side of a pump constructed to pump hot water (not every pump can do that), then you will feed water to a boiler without the company of air. Any person claiming to extract the air by any other process is getting trouble for the engineer-in-charge.

But "pitting" will be present still, though not so energetically, being the work of carbonic acid, which will be partly (but not wholly) liberated by the process of boiling in the open air.

When a pump takes its suction under pressure through long pipes, the water is suddenly checked during the action of the pump, with great force. By all means put on an air chamber.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Upper Carbon Packing Seal in a Curtis Turbine.

In most cases the upper carbon-packing seal in a Curtis turbine starts from the back bonnet of the controller-valve casing, on the overload side, and passes through the armature base to the packing case of the shaft. After the governor begins to perform its work all the valves are closed, and are reopened as the load demands; and under all conditions of load there is a pressure equal to the pressure in the steam pipe in the valve casing. The steam seal may begin at the point named and supply all the steam required to seal the packing, and there will be no objection to this method of supplying steam to the casing, until, possibly, the main throttle valve becomes closed from some unexpected cause. For instance, the weight may fall, or someone or something may strike the trip lever, or the trip lever may fall from excessive speed. When this occurs the steam supply to the valve casing is cut off and the packing no longer has its seal; and if the packing is a loose fit on the shaft, the vacuum will drop and, naturally, the condenser become hotter. The amount of this drop in vacuum, of course, depends upon the condition of the packing.

It is also to be remembered that when the machine is at rest and a vacuum is being formed previous to putting the turbine into service, there is no way of applying a steam seal to the carbon packing at the wheel-casing head, for all the valves leading into turbine are open and there will be no pressure in the valve casing for the purpose. On the other hand, there will be a vacuum on the entire machine, extending back into the steam pipe leading from the throttle.

It appears to me that at the time of obtaining a vacuum, or when there is a vacuum on the entire machine, the steam seal is needed most, and for that reason I have piped the steam seal from behind the throttle valve, where a constant pressure is to be had. You will at all times have your steam seal on packing regardless of what conditions exist on the machine.

Before starting up, the seal may be applied; and I know from experience that a much better vacuum can be obtained by having a seal on the machine. If we do not form this seal from some steam pipe with constant pressure, it is plain that no seal can be afforded the packing until the governor is controlling the machine and the valves have been closed. In most cases (not all) only a few seconds elapse after the machine has reached speed and is being governed by its governor, before it is in multiple with other units (or on the line with a load by itself), and it naturally has a pressure in the first stage which will answer for a seal, unless the load is a varying one and falls off to where a vacuum has formed in the first stage. This, I think, is very seldom the case, however.

Often engineers who operate turbines of the vertical type are not well posted regarding the amount of pressure that should be carried on the lower carbon packing. I have seen cases where from 12 to 16 pounds pressure was carried, and in one case of this kind the chief complained about having to draw a great deal of water from the oil filter. It was decided to look into the packing in the exhaust base, as this seemed to be the only source from which water could get into the oil. The machine in question was shut down and the packing removed from around the shaft. It was found that directly in line with the opening in the casing where the steam of 16 pounds gage pressure was admitted there was quite a hole in both packing rings, having been cut by this excessive pressure coming in direct contact with the rings at this one point. The condensed water as well as live steam had a direct passage into the exhaust base; also into the chamber where oil is discharged from the top of the guide-bearing, and it was here that the oil came in contact with the live steam and condensed it. Thus the temperature of the return oil became high, and, naturally, water went back with the oil. Had only water passed the lower carbon ring this would have been deflected by a ring located on the shaft below the packing for that purpose, and then carried off to the sewer through the drain pipe.

The condition of the packing that had been taken out called for new, which was installed, and it was then decided to try a seal pressure of two pounds. This done, the vacuum was found to be the same as when the 16 pounds had been applied. The oil temperature was a great many degrees lower, and no water was known to return with the oil. It was then decided to increase the pressure in order to learn if the vacuum would be benefited, or augmented, but increasing the pressure made no difference; the vacuum was constant. The pressure was then put back to two pounds and kept at that, with excellent results. One pound above atmosphere will do as well as 15 or 20 pounds, as far as the vacuum is concerned, and, as seen, two pounds will not damage the rings at all. As long as one pound seal is registered, and the gage is accurate there can be no vacuum.

SINCLAIR WORTH.

Philadelphia, Penn.

Economical Lubrication

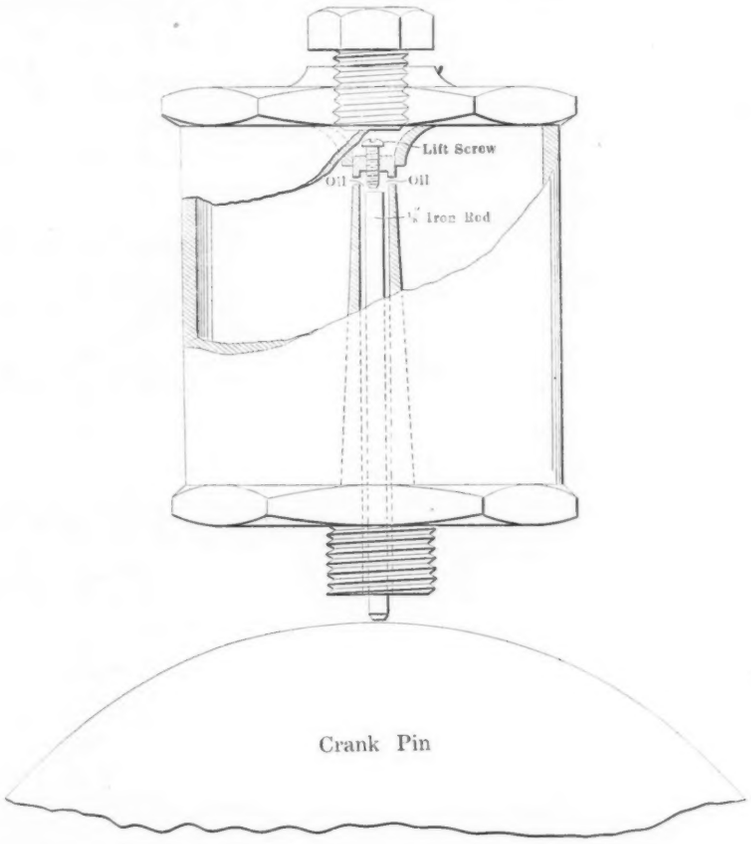
At a little gathering of engineers a few weeks ago, after discussing various engine-room topics the question of economical lubrication came up. The talk that followed recalled to the writer what he thinks is one of the cheapest instances of lubrication on record.

It was an 18x42 Reynolds-Corliss engine, making 85 revolutions per minute. On taking charge of the plant one of the first things that the writer noticed was that the only way of lubricating the crank-pin was by means of an oil cup screwed onto the strap. There was no center oiler, and as the engine drove by means of a jack-shaft a number of arc-light and incandescent machines and was in continuous operation from twelve to eighteen hours out of the twenty-four, according to the time of year and the weather, I naturally felt somewhat alarmed as to the possibility of the cup running empty and the pin getting hot, and asked if it was customary to shut down once in a while to fill the cup. But on being assured by the superintendent that they never had any trouble with it on that score, I started up in the afternoon for the night's run; but the fact that the continuous operation of the engine and the dynamos with their hundreds of lights depended on that little cup with its few ounces of oil made me so cautious and watchful that I gave the crank-pin very close attention, feeling of it every few minutes.

In the morning, after shutting down the engine, I was greatly surprised to find that instead of the cup being empty it was still nearly full; in fact, not more than a spoonful of oil had been used, and

at no time during the run was the temperature of the pin above that of the room. As I became more used to it I let the cup run a whole week before filling, and even during hot weather or long nights in the winter, we found that the cup was never more than one-half empty after a full week's run.

The construction of the oil cup as I remember it (this was 20 years ago) is shown in the accompanying sketch: A glass body resting in a brass case with an iron rod or pin about ⅛ inch in diameter, the lower end of which rested on the surface of the crank-pin. This rod was inside of a tube that was about 1/16 inch larger in diameter than the rod. The action of the crank in revolving caused the rod to rise and fall slightly, thereby



OIL CUP AS MR. DAVIS REMEMBERS IT

causing the oil which had been splashed against its upper end through openings in the case or tube to feed slowly but continuously down the rod to the crank-pin surface. The amount of lift was regulated by means of a small screw, as shown in the sketch.

The recollection of this cup and my experience with it induced me to figure out what it must have cost to lubricate this crank-pin. Here are the figures: The cup did not hold more than 4 ounces of oil and, as I have stated, it was never more than half empty after a week's run. We will assume that it used 2 ounces of oil a week, or 8 ounces a month. A gallon of cylinder-oil of 25 gravity (Baumé) weighs 7.53 pounds, or approximately 7½ pounds, or 120 ounces. The oil, as I remember it, cost us 50 cents per gallon. At the rate of 8 ounces a month, a gallon, or 50 cents' worth, would last 15 months, costing 3 1/3 cents per month. Now an ordinary cylinder stock or engine oil would have answered just as well at a cost of about 15 or 20 cents a gallon, and by means of the regulating screw not any more would have been used, in which case the cost would have been about 1⅓ cents per month.

WILLIAM M. DAVIS.

Boston, Mass.

A Simple Problem in Mechanics

In the first arrangement of John H. Manning's problem, on page 832 of the May 26 number, each piston having 10 square inches area, with steam at 40 pounds pressure per square inch, the spring scale will show a pull of 40 × 10 = 400 pounds. Assuming that one piston is stationary the steam would force the other piston out with a force of 400 pounds. This same force would also react against the stationary piston. When both pistons are movable the result is the same, as one of them simply forms a head for the steam to react on, or I might say to kick against, while pushing the other.

This problem may be likened to the old problem of hitching a rope to a tree and, placing a man on the free end, let him exert a pull of 100 pounds. We can all see that the rope is stressed by a pull of 100 pounds, and also that the tree has to resist the same pull. If, now, we substitute another man for the tree he will have to pull the same amount the tree did. In other words, he will have to exert a pull of 100 pounds. If he does not, he will be drawn toward man No. 1. Now, if he is only pulling what the tree resisted (100 pounds) the strain on the rope is the same as before. The two pistons represent the two men and the spring scale and connections represent the rope.

In the second arrangement the spring scale will also show 40 × 10 = 400 pounds pull. If a block of wood is placed behind the piston on the left and steam is admitted behind the piston on the right, the spring scale will show a pull of 400 pounds, and the block of wood behind the piston on the left will have to resist this pull. Now if the block of wood is removed and steam at a pressure of 40 pounds per square inch is admitted in its place, the pressure exerted by the steam can only be 400 pounds, or just the same as the block of wood had to resist; therefore, the steam cannot force the piston toward the right, as it requires all of this force to hold it from being drawn toward the left.

LESTER A. FITTS.

Shirley, Mass.

In Mr. Manning's left-hand sketch the spring scale will show 400 pounds. In the right-hand sketch there is no outlet shown from between the pistons to the atmosphere. The pistons are air-tight, or they are not air-tight. If they are not air-tight the air will leak by them until the pressure between the pistons is 40 pounds; consequently, the scale will show no pressure.

If the pistons are air-tight, as soon as they begin to move they will compress the air between them; consequently, the spring scale will show considerably less than 400 pounds.

RICHARD J. FLINN.

West Roxbury, Mass.

In the first case, one piston will act as a head and the pressure exerted on the spring scale will be 10 × 40 = 400 pounds, neglecting friction. In the other case, the two pistons must balance each other; therefore, one piston merely acts as a starting point for the second piston to pull against. The pressure on this scale will be the same as the other one. In either case, the spring will have to be strong enough to stand a pull of the area of piston times the pressure in pounds per square inch.

J. C. HAWKINS.

Elyria, Ohio.

The pressure on the scales in both cases is 40 pounds times 10 square inches equals 400 pounds. Because one of the pistons in each of the cylinders acts the same as a

cylinder-head, there can only be 400 pounds recorded on the scales, instead of 800 pounds which would seem probable at a first glance at the problem.

JAMES E. KILROY.

Lincoln Place, Penn.

I think the scales will both register the same, as follows:

$10^2 \times 0.7854 \times 40 = 100 \times 0.7854 \times 40 = 78.54 \times 40 = 3141.60$ pounds, neglecting any resistance. The use of the pulley as shown does not help in leverage.

I. NONITT.

Los Angeles, Cal.

Cement and Concrete for Boiler Setting

After reading Mr. Blakney's article in the May 5 number of POWER AND THE ENGINEER, it is evident that the Northwest can give us some clever wrinkles, but in going over the details of construction the writer has noted some points in which there seems room for further improvement. The method given for making the forms is too "rough and ready" to make a neat job, and the 2x4-inch uprights, braces and top pieces will make up quite a lumber bill. Green yellow pine or spruce in the shape of matched boards planed on one side should be used against the wet concrete, for otherwise the dry wood will warp, swell and pull apart. Instead of nailing pieces across the tops of the uprights to prevent bulging, would it not be better to bore two holes in each piece and loop a wire through, fastening the ends tightly? The form can then be drawn as close as desired and securely held by placing a large nail or piece of wood between the wire strands and twisting them together by turning, afterwards fastening it so the wire will remain taut. When removing the forms the wire may be cut at the side to facilitate the work.

Butting the fire-brick up against the concrete setting (see Fig. 2) provides no air space between to prevent radiation of heat, so that in time the concrete would inevitably crack. For this reason a 2-inch air space should be provided, as in Fig. 3. By laying two courses of fire-brick instead of one, with an arched setting to receive the boiler lugs at the desired hight, the boiler may be supported in the usual way, instead of suspended from the timber.

In place of wooden forms, iron or steel plates of the proper hight may be used to advantage, these to be set up in sections, fitted together with tightly butting edges and with angle plates riveted on and bolted together at frequent intervals on the top, bottom and sides, as in Fig. 4. Allowance should be made on the inside plate for the brick bond shown every third or fourth course in Fig. 3.

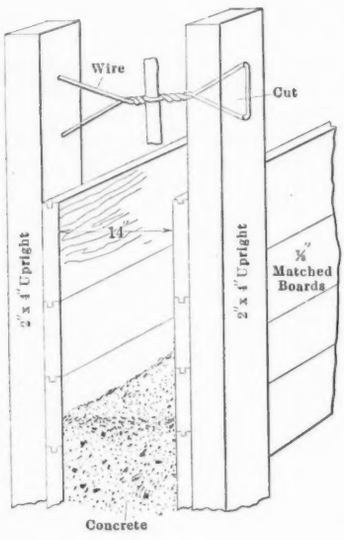


FIG. 1

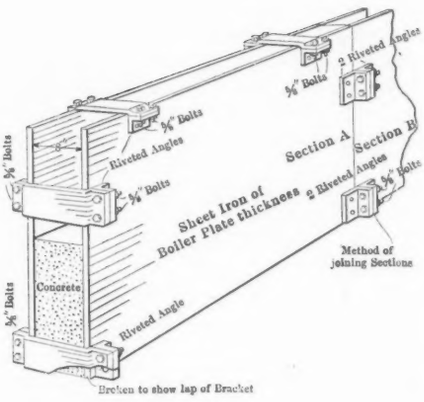


FIG. 4

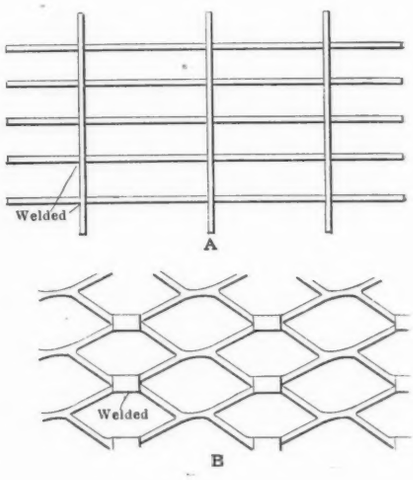


FIG. 5

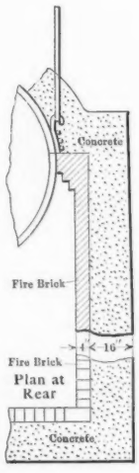


FIG. 2

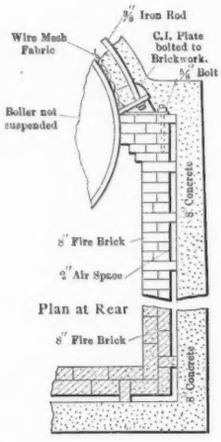


FIG. 3

ture of the crown of the setting, would be better construction. The rods are fastened by screw-bolts through long, bent angles bolted into the top of the brickwork, as shown in Fig. 3.

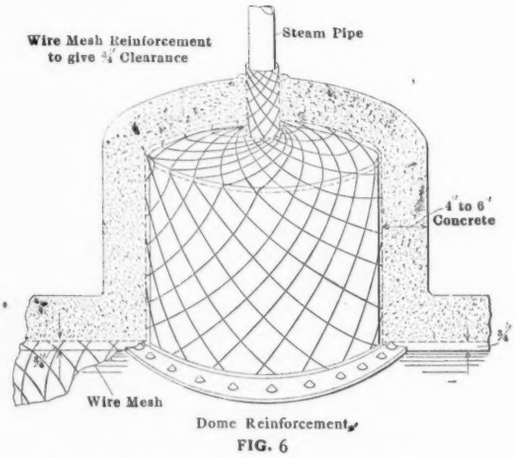
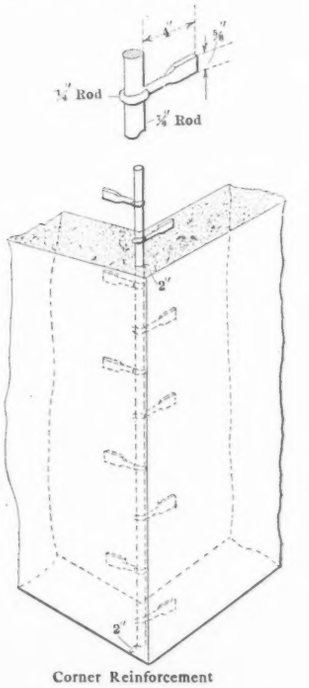


FIG. 6

The suggested reinforcement in the boiler arch of broken slag and furnace scrap and junk would tend to make the covering too uneven and wanting in uniformity for a place requiring particular care. Re-inforcing these arches with ⅜-inch iron rods, set not more than 4 inches apart and bent to conform to the curva-



Corner Reinforcement

FIG. 7

To provide an air space and for convenience of removing the insulating material, a form of wire mesh or netting is often laid under the concrete. Two typical wire reinforcements are shown at *A* and *B*, Fig. 5, and the placing in correct position is shown in Figs. 3 and 6. The mesh is stretched over the boiler and held about ¾ inch above it on top of building paper, and the concrete is then placed over it. In Fig. 6 the wire mesh also includes the dome, and a small sleeve incloses the steam pipe entering the dome.

In Fig. 7 is suggested a form of reinforcement for the corners, consisting of a ⅞-inch rod set down about 2 inches from either outside face and having at intervals of 4 to 6 inches alternately ¼-inch rods flattened spade-shape and projecting parallel to either face. This rod is set in the corners of the mold and held in place by wires at top and bottom. A corrugated iron bar could be substituted by setting it nearer the outside faces.

F. W. MARTIN.

New York, N. Y.

A Method of Finding Water Evaporation.

The accompanying sketches illustrate a rough method of finding the water evaporation. In Fig. 1 *A* is an old oil tank, *B* is the pump suction, *E* is a water pipe under town pressure. I carefully marked the glass of the tank, so that the distance between the higher and lower oil-level marks is equal to 100 pounds of water. After filling the tank by means of the pipe *E* the valve *C* is closed and the valve *D* opened. The pump is started, and when the water comes to the level of the upper mark, the number of strokes it makes to pump the water to lower mark is carefully noted, and jotted down on a slate alongside of the pump.

It now only becomes necessary to know how many strokes the pump makes during the day's run. To count these I took an ordinary revolution counter and made a tight-fitting collar to go over the spindle *F*, and to which was fastened the spoke *G*, as shown in Fig. 2. A ⅞-inch cast-iron plate *H* was found and a small parallelogram chiseled in the middle of it, as shown in Figs. 2 and 3, the grooves being about ½ inch in depth. A 7/16-inch rod *K* was fastened to the rocker-arm (Davidson pump) and a piece of ½-inch pipe *L* made a loose fit over it. A washer *M*, a light spring *N*, and the fastening of the pins *O* to *L* (*O* being made to loosely fit the grooves) completed the job. The pin is kept central when at the end of its stroke by gravity and the spring *N*. Thus it is sure to strike the right and left sides of the parallelogram, and, of course, causes the spoke *G* and consequently the spindle of the counter to make a complete

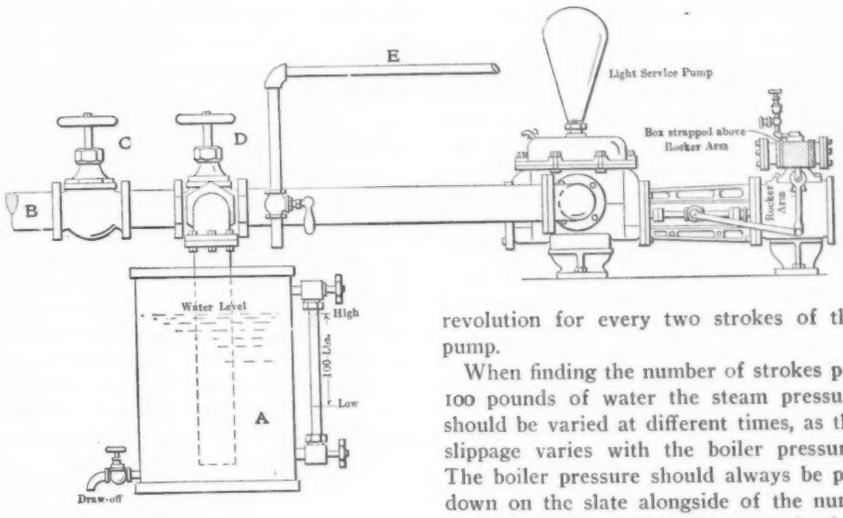


FIG. 1

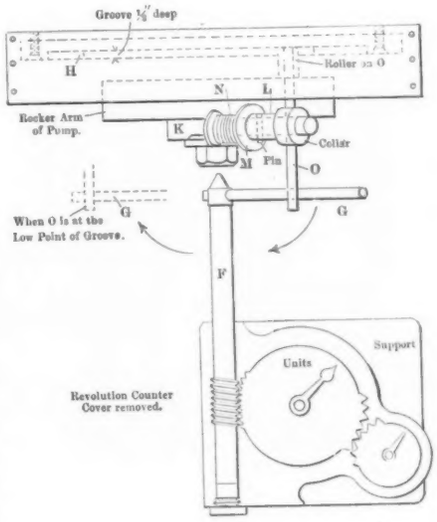


FIG. 3

revolution for every two strokes of the pump.

When finding the number of strokes per 100 pounds of water the steam pressure should be varied at different times, as the slippage varies with the boiler pressure. The boiler pressure should always be put down on the slate alongside of the number of strokes. The whole mechanism was inclosed in a cigar box mounted, as shown in Fig. 2.

R. O. RICHARDS.

Framingham, Mass.

Engineering Information as the Public Gets It

I wish to add two "gems" of engineering items, copied from a California daily, to Mr. Barrington's article on page 827 of POWER. In one of these the reporter, in describing a steamship accident, writes:

"The gigantic belt having slipped off the boiler, the engine became unmanageable and blew the relief valve off the cylinder-head. The first assistant went down into the *bilges* to repair it, and owing to the intense heat it was necessary to play a hose on him to save his life." The engineer who gave out that report must have enjoyed himself, although it appears impossible to believe anyone could be so ignorant of engineering as not to realize he was being filled with "hot air."

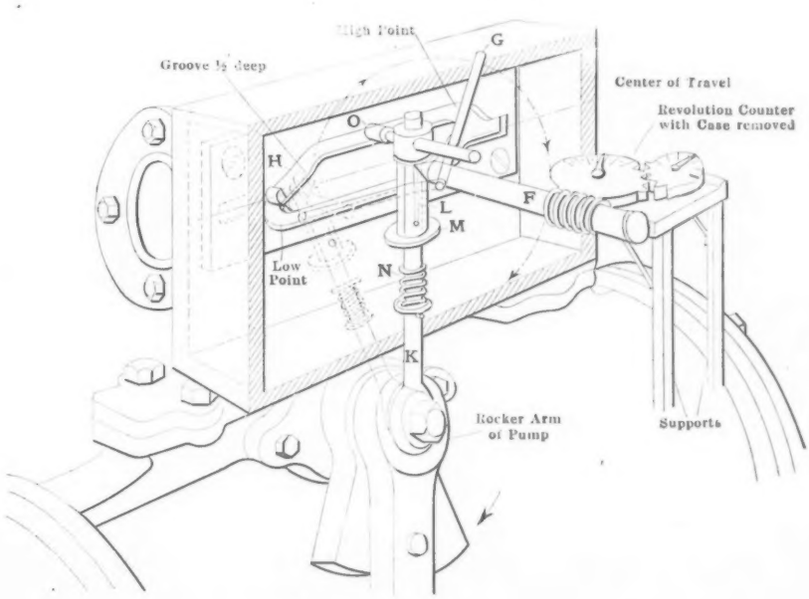


FIG. 2

Another paper described the location of a break in a submarine cable as follows:

"Enormous dynamos capable of manufacturing many millions of ohms are attached to each end of the faulty cable. These dynamos pump ohms into the cable until the meters show that the cable will hold no more. The fault is then found by comparing the number of ohms each half of the cable contains. If the two amounts are the same the break is in the middle of the cable, but if one is twice the other, the break is located two thirds of the way from the end where most ohms were pumped in."

It is easy to see that the information given to the reporter was O. K., but disaster occurred when he tried to put it in his own language.

R. H. FENKHAUSEN.

San Francisco, Cal.

A Simple and Effective Oil Filter

A few years ago a small lighting plant was installed where the writer was employed. Two old boilers, set for heating purposes, were arranged to use with high pressure. When the engine was installed the exhaust was put through a 3-inch coil. This coil of pipe was supposed to take the oil out and deliver only steam into the heating system, where it went, oil and all. All went nicely for a few months, and then the boiler we were using began to buckle. Then we noticed that the rivets leaked over the fire at the first lap and we did not fire up to high pressure again with that boiler, but used it for heating. We had changed off, so both boilers were buckled some.

All at once the front manhole began to leak in the boiler we were using, and the leak could not be stopped. We found that the front head had been sprung out of shape by the buckling of the sheet over the fire. A pressure tank for water was needed, so we pulled the boiler out and replaced it with a new one. By the time we got the old boiler out where it could be examined the results of the oil in the feed-water were very plain. The old boiler makes a good water tank, but it was a big job to get the water and air to remain on the inside.

To prevent oil from getting into the new boiler, we purchased a standard oil separator and put the coil into a cement tank. The steam, after passing through the oil separator, passes through the coil in the cement tank, and then to heating system. The condensed water is returned by gravity and is fed into tank by a float valve. The water is allowed to run from the float valve into a tile, one end filled with excelsior and brickbats. This is a safeguard to insure no oil in feed-water. The oil separator is guaranteed to remove enough to render the condensation fit for boiler purposes, but in case these statements might be a little "strong," we use this filter. The water is well heated by the coil in the tank and then pumped to the boiler. We have had no trouble with oil since.

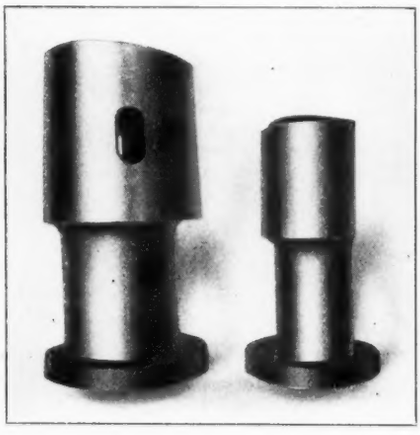
W. J. WHITCOMB.

Monroe, Wis.

Worn Crank Pins

One sees peculiar happenings in the engineering field, some of a seemingly mysterious nature and others easily understood at first glance. The illustration shows two crank-pins which were badly worn before new ones were substituted. The larger was taken from a side-crank 12-ton ice machine.

The engineer who took the plant to operate after a strike, found the clearance on one end to be 3/16 inch, while that on the other end was considerably less. This gave the compressed gas a chance to expand and the constant pressure against the piston prevented the crank-pin from being properly lubricated. Another cause



WORN CRANK PINS

for the wearing of the pin was undoubtedly due to the poor grade of steel used in its construction. Originally this pin was 2¾ inches in diameter, and it was worn down to 2¼ inches, the wear being all on one side.

The smaller pin was taken from the crank of a 25-horse-power engine. The engineer attributed the wearing of this pin to faulty valve setting, one end of the valve having excessive lead, while the other end had none. The result was that most of the work was done on one end of the cylinder, which caused the greatest pressure to bear on the pin at the same point at each revolution. The pin also shows that the quality of steel used in its construction was more fit for shafting than for crank-pin use. This pin had an original diameter of 2 inches and was worn down to a diameter of 1⅝ inches.

With this excessive wear, it was, of course, impossible to operate the engine without considerable knocking. On one occasion the engineer was forced to rebabbitt the brasses, and as there was no proper mandrel at hand, an ordinary piece of steam pipe about the size of the pin was screwed into an old-fashioned set of thread dies, and the brasses centered around the piece of pipe. The babbitt was then poured, scraped and the brasses put in place. This makeshift lasted until a new crank-pin was put in and new brasses obtained.

M. EASTMAN.

Cleveland, Ohio.

Finding Steam

When you are an employee of a large concern manufacturing the latest and best kind of power and electric apparatus, you come to consider, that because of its rank in size and importance, everything concerning it is *par excellence;* that, since it is a leader and growing and progressing rapidly, the manufacturing efficiency is as near to the 100 per cent. mark as possible.

Such was the state of my mind until, perchance, I came in close contact with actual conditions affecting our "coal pile," which have shown the rankest negligence and disregard of ordinary common-sense usage in steam fitting and piping. Twenty-five hundred dollars ($2500) per month has been saved in this coal pile feeding our 9000-horse-power equipment.

While investigating the cause of coal extravagance I ran up against an interesting condition. The power house proper receiving the undivided attention of an expert, I turned my attention to the shop uses. The first few days I endeavored to become familiar with the various pipe lines feeding the different portions of the shop. I nosed around trying to ascertain the best method of procedure in finding and measuring the uses and abuses, until, by accident, I had it forced upon me.

I was standing outside of a building in which six steam hammers were working, and in which a line led to several heaters about the building. I noticed a cloud of steam coming from a gutter and giving me the clue that evidently a great deal of steam must be pouring out into the sewer near the place where this gutter entered. Following it up, I found a manhole and upon removing the cover-plate a cloud of steam rushed out and I heard down in the hole the blow and sputter of a steam pipe discharging into water. The steam blinding me, I went inside the building and tried to find the spot where I could cut it off, but all the valves were leaking, so I called upon the foreman of the pipe fitters. He and two or three of his men uncovered a hole next to the manhole and showed up a steam trap.

"This is slightly out of adjustment, and er-blowin steam a little," he said, as he turned off the valve on the inlet to the trap and stopped the cloud of steam that was enveloping us.

"Yes," I answered, "quite a LITTLE."

He tinkered and adjusted the trap and

explained to me that it was used to drain the heaters in the building. His work on the trap being of no avail, I suggested looking at the valves. (Luckily the construction of the trap was such that it could be easily got at—a feature that it is well to note in buying traps, for a great deal of work is occasioned by having to disconnect the trap entirely from the line in order to look at or adjust the valves.) As I expected, they were worn and were drawn all out of semblance, causing the trap to blow steam straight through and, of course, occasioning a great loss of steam, as 165 pounds pressure was back of this source of loss.

We had a new seat and valve-stem put in and everything was again O. K. I laughed up my sleeve as the lead-pipe fitter explained to us how "bad this water is on valves," and that it hadn't "been a month since a new stem was put in there," and "his trap man was inspecting that trap last week, and it was all right then."

After putting the pipe fitter through a series of questions I found that there were some seventy-five or more traps in the place and here concluded that by going to each of these traps, measuring the discharge and noting, at the same time, the condition and service of the apparatus it drained, I could get a very good line on the uses and one that was quite accurate. But traps are "trappy" and there were more discoveries ahead for me, which I may tell about later.

WILLIAM LONGSTREET.

Wilkinsburg, Penn.

What Caused the Lamps to Flicker

To the inquirer who had an article in the April 21 number on "What Causes the Lamps to Flicker?" I would suggest that he look carefully to his driving belt. Alternating-current generators require special belts, on account of the great velocity at which they run. They should be endless, with absolutely no abrasions or rough places whatever, and be kept soft and pliable. Unevenness in texture and thickness, also excessive friction due to too great adhesive qualities of the belt, will cause flickering of the lamps. A leather-covered pulley should never be used on alternating-current machinery, as it produces too much resistance. Rather use a plain, polished-iron one.

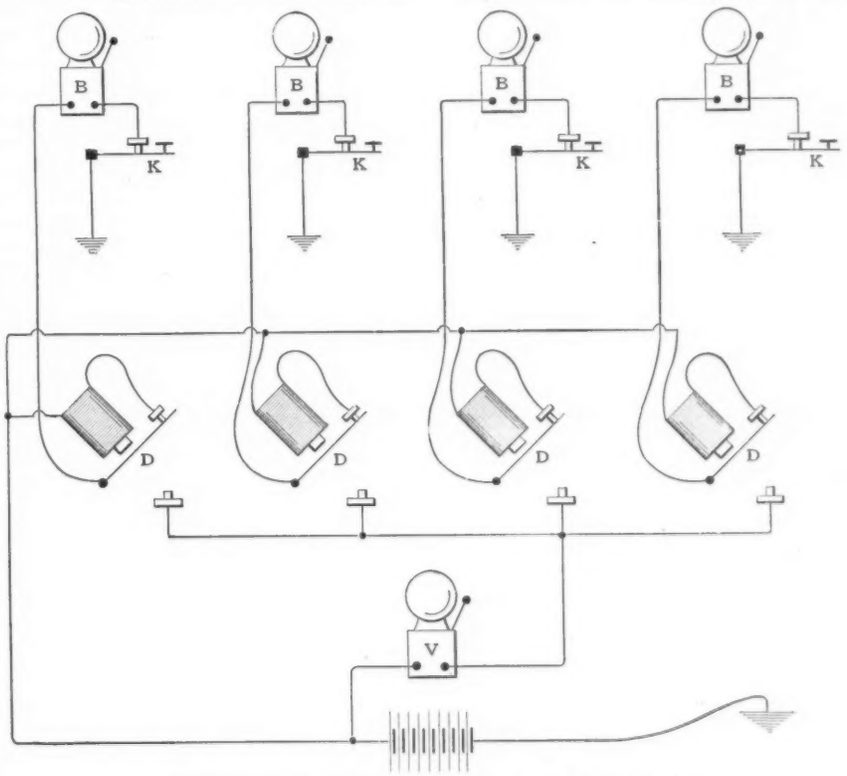
A "short" in one pair of poles in an alternator will also produce flickering lamps by reducing the number of complete alternations per second; also, the presence of static electricity will do the same thing, and if this latter is not looked after and removed in time it may destroy the machine; but from the article in question I am not inclined to think that either of the two last-mentioned causes is troubling the writer.

J. L. BRADSHAW.

Memphis, Tenn.

Solution of "A Wiring Problem"

Referring to Mr. Harrison's problem in signal circuits, published on page 791 of the May 19 number, I would say that the results he desires cannot be obtained in the way he indicates without using a rather complicated system of relays. The accompanying diagram shows one way of getting what he wants with simple apparatus, however. At each sub-station is located a 5-inch *single-stroke* bell *B*, and a key *K* which keeps the circuit normally closed to ground. At the central station are four circuit-closing annunciator drops *DDDD*, a 5-inch vibrating bell *V* and the 10-volt battery. The battery keeps all the drops closed as long as the circuits are intact. If the key *K* at any sub-station be depressed, that circuit will be opened and the drop corresponding to that station will fall, connecting the station to the bell *V*. As soon as the key is released, closing the circuit again, the bell *V* will ring, and its vibrator will also cause the single-stroke bell *B* to ring. This will continue until the drop at the central station is restored to its closed position. As all of the circuits are in parallel with each other, the operation of one of them will not affect the other three.



MR. MALCOLM'S SOLUTION OF "A WIRING PROBLEM"

The resistances of all four circuits should be equal in order to equalize the current flow in them. This can be accomplished by inserting dead resistances in the shorter lines, preferably between the annunciator drops and the outgoing wires at the central station.

GEORGE W. MALCOLM.

Brooklyn, N. Y.

An Appeal Examination

Having been asked for correct answers to the eight questions on page 745 of the May 12 number, I take this method of replying.

1. "If you attached a steam gage to the steam-chest of a slide-valve engine and a gage to the steam-chest of a Corliss engine, what pressure would each register? Steam pressure on the boiler 120 pounds, no 'drop' of pressure in the piping."

On the steam-chest of a slide-valve engine the gage would show the pressure necessary to keep the engine up to speed. On the steam-chest of a Corliss engine boiler pressure would be registered.

2. "How many positions is a Corliss governor capable of assuming?"

Any number; the critical positions are the highest position, on the stop and below the stop.

3. "What could cause a water-glass to show three gages of water when the gage-cocks showed only two, the valves being open and the openings ample in size and clear?"

Leakage of steam from the upper gasket or anything that would tend to reduce the pressure in the upper part of the glass or its connections to the boiler.

4. "Why do the makers of pumps having both valve-decks above the cylinder, make the space between 'decks' so shallow as to inconvenience a repairman when replacing a suction valve?"

To reduce the clearance and to make the cylinder as compact as possible.

5. "What part of a 'B. & W.' boiler gives out first?"

Usually the mud-drum nipples or the tubes.

Longitudinal seam of the steam drum.

7. "Figure the safe working pressure of a horizontal return-tubular boiler 72 inches in diameter, ½-inch sheets, 60,000 pounds 'T. S.,' and triple-riveted, double-butt strap joints. Assume the pitch of rivets, etc."

Diameter of the rivet hole, twice the thickness of the sheet; pitch, three times the diameter of the rivet hole; pitch of outer row, twice this.

$$\textit{Joint efficiency} = \frac{\textit{pitch} - \textit{diameter of rivet hole}}{\textit{pitch}}.$$

$$\textit{Bursting pressure} = \frac{\textit{thickness} \times \textit{tensile strength} \times \textit{joint efficiency}}{\textit{radius}}.$$

$$\textit{Safe working pressure} = \frac{\textit{thickness} \times \textit{tensile strength}}{\textit{radius} \times \textit{factor of safety}}.$$

Substituting:

$$\textit{Joint efficiency} = \frac{6-1}{6} = 0.833.$$

$$\textit{Bursting pressure} = \frac{0.5 \times 60{,}000 \times 0.83}{36} = 691.66 \textit{ pounds}.$$

$$\textit{Safe working pressure} = \frac{5 \times 60{,}000 \times 0.83}{36 \times 4} = 172.9 \textit{ pounds}.$$

8. "Find the safe working pressure of the same boiler without tubes or stays."

The bursting pressure of flat unstayed cylinder-heads =

$$\frac{\textit{thickness} \times \textit{tensile strength}}{\textit{area} \times 0.09}.$$

The safe working pressure of a 72-inch flat head ⅝ inch thick =

$$\frac{0.625 \times 60{,}000}{4071.50 \times 0.09 \times 5} = 20.48 \textit{ pounds}.$$

JOSEPH KING.

Boston, Mass.

Cylinder Lubrication

In the June 2 number, page 867, are several replies to John L. Sheldon's request about lubrication. I will give my experience with an engine which was built from my design and drawings (the size is of no consequence, as that is nothing to the point) and it ran with wet steam, for 16 years, *without applying one drop of oil while the engine was in motion.* The cylinder and valve were, at first, examined every Sunday; but as the cylinder, piston, port and valve faces became more like burnished silver, as time passed, we examined them when we got time. The results varied not a tenth of 1 per cent. The valves were scraped, not "emeried." So I agree with Mr. Sawford that it is best to use as little oil as possible. In our machine there was not one oil hole or cup, so it was not possible for any oil to accumulate. In his seventh paragraph he agrees with Mr. Strohm. I do not object; but the engine of which I have written was a horizontal engine.

Now for the finale! My protégé, the engineer, died and was buried. Another, whom I knew not, took his place. Horrified at finding not even *one* oil hole, he drilled several, put on all the contraptions in use at that date (1857-73) and in two years the engine adorned a scrap-heap, being an oil-grooved wreck.

The oil of those days contained acid, in various proportions, which accounted for the termination.

PETER VAN BROCK.

Jefferson, Ia.

Three Interesting Cards

I submit the accompanying cards for criticism by readers of POWER AND THE ENGINEER. They were taken from a Westinghouse automatic compound engine. Fig. 1 was taken with about one-third normal load, Fig. 2 with normal load, and Fig. 3 with about 50 per cent. overload. The engine is direct-connected to a direct-current generator on railway work.

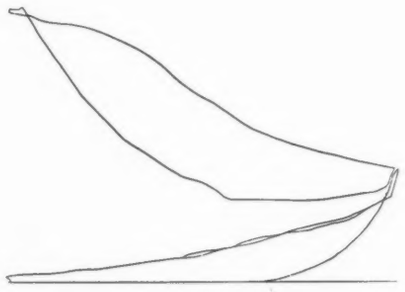


FIG. 1

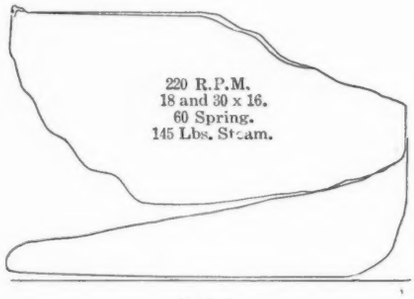


FIG. 2

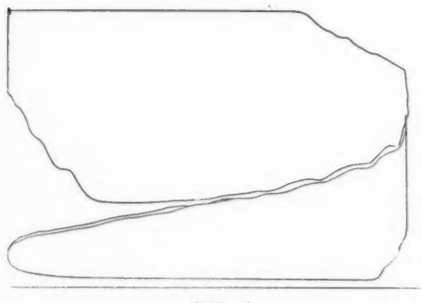


FIG. 3

CHARLES E. NIGH.

Morgantown, W. Va.

Varying Hight of Diagrams

How can one tell the head end from the crank end of an indicator diagram? When I stepped into the engine room of a friend of mine recently, I told him that if he would produce some diagrams I would tell him which was the crank end and which the head end, which I did. There are plenty of engineers to whom this subject is new, and it may seem strange to some, who have not had the opportunity to measure and compare the hight of both ends, up to cut-off, of different indicator diagrams taken under entirely different conditions and from engines with entirely different valve-gears. It is a fact that with engines with direct valve motion, where the eccentric does not follow the crank but leads it, the crank end will measure the higher; while with indirect valve-gears, as of piston valves taking steam in the center and exhausting over the ends, the eccentric follows the crank, or if passing a reversing rocker, it leads the crank. With the Greene engine, the eccentric follows the crank and moves the sliding bar in the direction opposite to that in which the piston moves when taking steam, making it practically indirect, though not possessing a rocker-arm. For illustration, I have indicator diagrams taken from the old Brown, new Brown, Rollins-Putnam, Atlas and Ball & Wood engines and four different makes of Corliss engine from three to fifty years old, running at from 50 to 250 revolutions, including, also, a G. H. Corliss with quick-opening valve-gear, the crab-claw, the original Corliss and Nightingale, the Filer & Stowell and the Harris releasing-gear.

The question arises, why the difference in the hight of the two ends? The first reason is that the angularity of the connecting-rod is the cause of the piston moving slower on leaving and approaching the crank end and making it travel faster on leaving and approaching the head end. This slow movement on the crank end favors the higher pressure, as it surely takes time to attain boiler pressure. Then there is the area of the piston-rod, which takes up so much space, making less space to fill and giving more time to fill it, because of the slow movement of the piston.

Then we have the eccentric-rod; an eccentric is nothing less than a crank and is subject to distortional movements the same as the connecting-rod, only in a less degree. The movement of the eccentric-rod causes the valve to move very irregularly as the crank does the piston. Thus it will be seen that when the head end is taking steam, the valve is moving slowly, and on the other end the conditions are the reverse. When the piston is starting on the crank end, the eccentric is moving on its head end with great rapidity, which is another reason for getting so high an initial pressure in the crank end, because when the piston moves

fastest, the valves move slowest, and when the piston moves slowest the valves move fastest.

There are ways in which this irregularity can be improved, one of which is to put a rocker-arm in between the valve and eccentric, thus reversing the conditions—a fast-moving valve when the piston moves fast, and a slow-moving valve when the piston moves slow.

If you are not fortunate enough to own an indicator, borrow some diagrams from your friends and send to some indicator manufacturer and get a sample of his scales, which are true to the different springs. They are made of paper and usually sent gratis as samples; they are quite useful in measuring the hight, in pounds, of diagrams when figured by ordinates. It is essential that the valve-gear be as nearly correct as possible and that the indicator pencil have a needle point so that a fine line can be had, thus insuring accuracy. It is a very common thing to find diagrams made with a blunt pencil, and if a 60-pound spring is used, which means 60 marks to the inch on the scale, it will be readily seen how a wide pencil mark will take up more than one mark on the scale, making it necessary to average it. Measuring from the atmospheric line to the highest part of the card and at each end, and comparing the hights, there will be found from 1 to 5 pounds higher pressure on the crank end.

A. C. WALDRON.

Lynn, Mass.

Smoke Stack Troubles

Engineers in charge of small power plants seldom enjoy giving the "kid" credit for knowing anything pertaining to the operation of the plant. As a rule the smaller the plant the less is the boy supposed to know. The boy's duties are not very clearly mapped out, but he is expected to say nothing and work. He is supposed to run errands, wipe the machines and properly attend to all the duties ascribed to a "roustabout." Occasionally, however, things come to the notice of the "kid," which escape the eye of the chief, but when such observation is made known it is usually not very graciously received. This is borne out by an experience in which the writer was the "kid."

The plant in question was similar to lighting plants usually found in towns and villages of about 2000 inhabitants. It was of small capacity, having one 90-horse-power high-speed center-crank engine, belted to two generators. Steam was furnished by two 100-horse-power return-tubular boilers, which were connected at the stack end by an inverted Y breeching, on top of which was an iron stack 30 inches in diameter and 80 feet high. The stack had been in use about five years and had apparently been well cared for.

One morning when going to work, the writer noticed a small curl of smoke stealing its way out just beneath the guy-wire fastening on the west side of the stack. Nothing was said at first, but after watching the leak closely for three or four days the matter was called to the attention of the chief. He treated the matter lightly, merely grunting at my apparent meddling, so the incident was dropped. Two months went by before anything developed, when a high west wind tore out a small flap of steel which remained hinged on one side like a door, the guy fastening being near the free edge. From the ground it looked as though the wire might be pulled loose at any time. This time the trouble was reported direct to the manager, who was indignant, of course, to think things had been allowed to go so long without proper inspection, and a hurried visit to the plant was productive of "blue atmosphere."

No one could be found brave enough to ascend the stack and fix the fastening. It was finally planned to throw a long wire over the other three guy wires, and pull it gradually to the top, thus forming a temporary guy until one more permanent could be substituted. Before this was done, however, stormy weather set in and things looked bad for the stack. The wind was now accompanied by rain which continued for three days. The tearing out of the fastening occurred Thursday morning and the following Saturday night brought its usual peak load (opera house), but no change in the weather. The engineer hardly knew whether to start the plant or not as the stack was liable to fall at any moment.

The "third" was asked to stay until midnight and help fire. The wind increased as darkness came on, and at about 7:30 the stack came down with a crash. It fell directly across the plant and bounded to the ground. The Y breeching fell inward toward the coal pile, and would have probably landed on me had it not been for a joist running across the boiler room near the roof. This caught the breeching. Needless to say a 10-second man could not have beaten me out of that boiler-room. Near the engine I met the chief coming on the run, his face clearly showing that he was much frightened. The boiler room filled with smoke, and long flames darted from the ash-pit doors. It was some time before anyone could get near the fire doors, but finally some ashes were obtained and spread over the fires.

The entire Sunday following was spent in setting up 40 feet of the old stack, as this was all that was not destroyed. The plant ran this way for four months, and a brick stack was put up as soon as spring opened.

CHARLES R. MOORE.

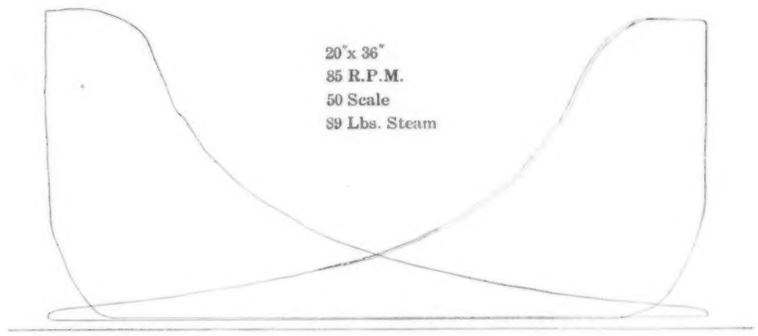
Lafayette, Ind.

Wants the Diagrams Criticized

The accompanying indicator diagrams were taken from a William Wright engine. I would like to have the readers criticize them and tell me how I can improve them.

G. H. LEE.

Jacksonville, Ill.



DIAGRAMS FROM A 20x36-INCH WRIGHT ENGINE

Steam Cylinder and Valve Lubrication

Daniel Chittenden's idea, in the May 12 number, on "Steam Cylinder and Valve Lubrication" is correct. I would further add that no engine, marine, stationary, locomotive, or any other type, will run as well without as with cylinder and valve lubrication. Several so-called tests have been made in recent years on marine engines, but all were futile in the extreme. Marine engineers are like the rest of us—they still have something to learn.

Recently a Government boat burned near Memphis. In the investigation held to try to learn the cause of the fire and place the responsibility, the report was given out by one of the engineers that "ammonia was the only combustible on board."

It was disgusting and no doubt surprising to many to think that as great an employer, and presumably so exacting a one, as the United States Government would hire an engineer so ignorant as to think that ammonia was a combustible compound.

J. L. BRADSHAW.

Memphis, Tenn.

Economy Tests of High Speed Engines*

Conditions and Results of Tests to Determine Economy and Efficiency of Non-Condensing Reciprocating Steam Engines in Actual Operation

BY F. W. DEAN AND A. C. WOOD

Several months ago it became necessary to make tests of several different high-speed engines, direct-connected to electric generators, for the purpose of determining the quantity of steam used per indicated horse-power per hour per kilowatt-hour, and to determine some other characteristics. The engines were taken as they were found, in order to ascertain their economy after having been run for some time, and as nearly as could be determined, the number of hours that they have been in actual running service is stated. It was not desired to do anything to improve the economy, or to remove any defects, except to equalize the work done at both ends of the cylinders, if they should prove to be unequal, by adjusting the lengths of the valve stems. The diameters of the cylinders and piston-rods, and the lengths of the strokes were measured.

The Engines Tested

The engines tested were of the types and sizes stated below, those numbered 1, 2, 3, 4, and 5 having been tested by Mr. Dean, and those designated by A, B and C by Mr. Wood:

1. 15 in. by 14 in.; 240 r.p.m.; horizontal single flat-valve engine with a 100-kw. d.c. generator on the shaft.
2. 16 in. by 15 in.; 240 r.p.m.; vertical single flat-valve engine with two 50-kw. d.c. generators on the shaft.
3. 14 in. by 12 in.; 300 r.p.m.; horizontal single flat-valve engine with two 40-kw. d.c. generators on the shaft.
4. 16 in. by 14 in.; 270 r.p.m.; horizontal engine with four flat valves, and having a 125-kw. a.c. generator on the shaft.
5. 12 in. and 19 in. by 14 in; 230 r.p.m.; vertical cross-compound condensing piston-valve engine with a 100-kw. d.c. generator on the shaft.

A. 18 in. by 18 in.; 220 r.p.m.; horizontal single piston-valve engine with a 150-kw. d.c. generator on the shaft.

B. 15 in. by 16 in.; 250 r.p.m; horizontal single piston-valve engine with a 100-kw. d.c. generator on the shaft.

C. 12 in. by 18 in.; 190 r.p.m.; horizontal engine with two flat inlet valves and two Corliss exhaust valves, and having a 75-kw. d.c. generator on the shaft.

*Abstract of a paper read at the Detroit meeting of the American Society of Mechanical Engineers, June 23 to 26, 1908.

These units are of types and makes frequently used in isolated plants in office buildings and elsewhere, and the results of the tests should give a very fair idea of the economy to be expected from such engines after they have been in use for some time.

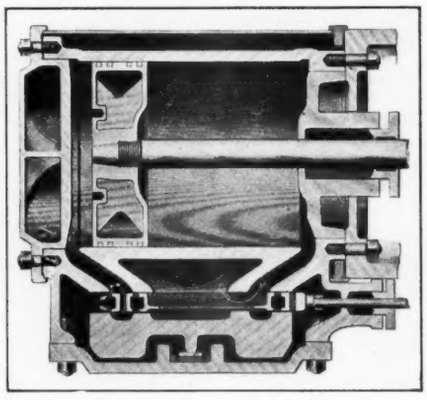


FIG. 1. SHOWING VALVE CHEST OF ENGINE NO. 1

The engines were supplied by steam from isolated boilers, except where the steam used was condensed. In the tests made on Nos. 1 to 5, the water was weighed on platform scales, and in the others it was measured in calibrated tanks. Water levels in boilers were maintained at as near a constant level as practicable. After the tests made by Mr. Wood were finished, leakage tests were made of the boilers and steam piping, but this was not done by Mr. Dean.

In order to avoid as far as possible inaccuracies due to differences in apparent quantity of water in boilers, due to any cause, the weights of water were plotted to see whether the resultant points were on a straight line or nearly so. In every case the results were satisfactory.

The quality of the steam was determined in every case, but no correction for this was made by Mr. Dean because in his opinion the results would scarcely have been more accurate thereby, but Mr. Wood applied corrections for entrainment.

Indicator springs were tested and corrections were made when necessary.

Electrical instruments used in all tests were carefully calibrated by comparison with standards.

Indicator diagrams and speeds were taken at frequent intervals.

The loads were maintained by water rheostats, except in the case of engine No. 1, where a steady lighting load was carried.

Tests of Engine No. 1

This is a simple horizontal non-condensing balanced slide-valve engine, running at 240 revolutions per minute, and direct-connected to a Fort Wayne electric generator, working at approximately 220 volts. The engine is used for power and

RESULTS OF TESTS OF ENGINE NO. 1.

1. Test No		4	5	6
2. Date	1907	Aug. 7	Aug. 8	Aug. 8
3. Previous length of service			1 5216 hours	
4. Size of cylinder			15 in. x 14 in.	
5. Diameter piston rod			2¾ in.	
6. Generator			Ft. Wayne d.c. 6-pole	
7. Generator rating			100 kw.–220 volts–400 amp.	
8. Duration of tests		2 hr.	2½ hr.	3 hr.
9. Approximate load		½	½	¾
10. Superheat of steam		7 deg. F.	14 deg. F.	12 deg. F.
11. Average steam pressure		83.0 lb.	83 lb.	81.5 lb.
12. Average revolutions per minute		242.9	240.8	240.3
13. Average temperature of steam		333 deg.	339 deg.	337 deg.
14. Average temperature of room		98 deg.	101 deg.	102 deg.
15. Average temperature of atmosphere		92 deg.	100 deg.	99 deg.
16. Average barometer		14.69 in.	14.69 in.	14.69 in.
17. Indicator spring, pound		60	60	60
18. Indicated horse-power		92.60	89.75	106.00
19. Indicated friction horse-power[1]				4.22
20. Indicated friction horse-power per cent.				3.98
21. Indicated horse-power to atmosphere		107.5	105.3	123.3
22. Average back pressure		4.3 lb.	5.5 lb.	4.6 lb.
23. Average cut off, per cent.		30.7	31.0	38.5
24. Average amperes		250.6	246.8	295.7
25. Average volts		222.5	222.2	221.2
26. Average kilowatts		55.8	54.8	65 4
27. Average kilowatts to atmosphere		66.4	65.0	76.4
28. Efficiency e.h.p. to i.h.p., per cent		82.3	82.3	82.7
29. Total water consumed, pound		8280	9771	13,384
30. Water consumed per hour, pound		4140	3916	4461
31. Water per i.h.p. per hour, observed pound		44.7	43.6	42.1
32. Water per i.h.p. per hour, to atmos., pound		38.5	37.2	36.2
33. Water per kilowatt per hour, observed pound		74.2	71.5	68.2
34. Water per kilowatt per hour, to atmos. pound		62.3	60.2	58.4

[1] Generator unexcited.

lighting and the load was sufficiently steady for test purposes.

As far as economy is concerned the most interesting feature is the slide valve. This is a long rectangular valve, the center being cut out, and ports cast through each end of the valve. The valve runs on edge and between the valve seat proper and a heavy balance plate held in place by steam pressure and by a heavy flat

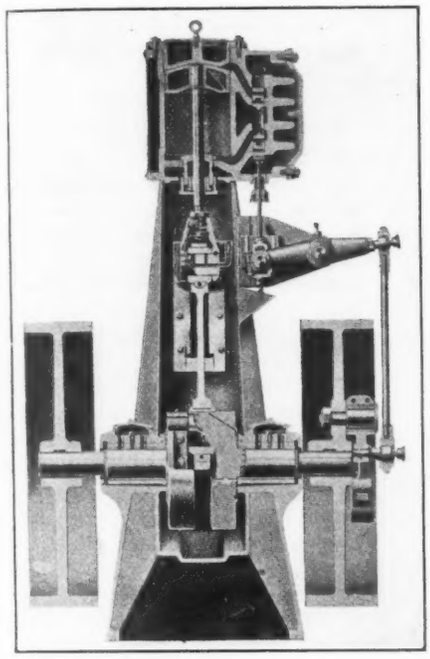


FIG. 2. SHOWING VALVE CHEST OF ENGINE NO. 2

spring. It is prevented from pinching the valve by strips of cast iron slightly thicker and longer than the valve, one being above and the other below the valve. In the balance plate there are depressions directly opposite the steam and exhaust ports, and of the same shapes and dimensions of those ports. Thus the valve is subjected to the same pressure conditions on one side as on the other, and is, therefore, perfectly balanced. It is also double ported on both steam and exhaust.

It will be seen that in order to render this valve tight the workmanship on the valve seat, valve, balance plate and distance strips must be of exquisite quality. If the valve should wear slightly it would leak and grow worse with further wear, for there is no means of this wear being taken up automatically as it proceeds. By scraping the distance strips the balance plate can be brought close to the valve again and the original condition of tightness restored.

As valves of this kind are perfectly balanced it is not expected that there will be much, if any, wear, but to what extent this is true I am unable to say beyond what may be indicated by the results of these tests.

The governor is of the fly-wheel type. The eccentric is moved in one direction by a weight subjected to centrifugal force, and in the other by a flat leaf spring connected to the weight by a flat steel band.

The feed-water was weighed in a barrel resting on platform scales and emptied into a lower barrel, from which a specially installed feed-pump drew it and forced it into one vertical fire-tube boiler. The feed-pipe was disconnected from other boilers.

RESULTS OF TESTS OF ENGINE NO. 2.

		7	8
1.	Test No.		
2.	Date	1907 Aug. 17	Aug. 24
3.	Previous length of service	20,000 hours	
4.	Size of cylinder	16 in. x 15 in.	
5.	Diameter piston rod	2½ in.	
6.	Generators	Two General Electric	
7.	Generator rating	Each 50 kw.–400 amp. 125 V.	
8.	Duration of tests	3 hr.	3½ hr.
9.	Approximate load	Full	¾
10.	Quality of steam	97.6	97.4
11.	Average steam pressure	75 lb.	75.6 lb.
12.	Average revolutions per minute	240.8	242.4
13.	Average temperature of room	96 deg.	82 deg.
14.	Average temperature of atmosphere	81 deg.	66 deg.
15.	Average barometer, inches	14.80	14.70
16.	Indicator spring	60 lb.	60 lb.
17.	Indicated horse-power	153.1	101.3
18.	Indicated friction horse-power.[1]	12.86	
19.	Indicated friction horse-power, per cent.	8.39	
20.	Indicated horse-power to atmospheric line	159.5	109.5
21.	Average back pressure	1.85	1.40
22.	Average cut off, per cent.	46.85	29.3
23.	Average kilowatt	91.2	55.3
24.	Average kilowatt to atmospheric line	95.8	61.0
25.	Efficiency e.h.p. to i.h.p., per cent.	80.0	74.2
26.	Total water consumed, pounds	17,154	14,093
27.	Water consumed per hour, pounds	5718	4027
28.	Water per i.h.p. per hour observed, pounds	37.3	39.7
29.	Water per i.h.p. per hour to atmosphere, pounds	35.8	36.7
30.	Water per kilowatt per hour observed, pounds	62.7	72.8
31.	Water per kilowatt per hour to atmosphere, pounds	59.7	66.0

[1]Generator unexcited.

The steam pipe from the boiler was equipped with two stop-valves, and a small bleeding pipe to the atmosphere was inserted between them. On shutting both valves and opening the bleeding pipe no steam escaped, thus, fortunately, showing both valves to be tight. A special pipe was run from a flanged nozzle on the boiler steam pipe to the engine, and therefrom the regular steam pipe was disconnected.

As the boiler was of the vertical fire-tube type the steam was somewhat superheated at the engine.

It was considered of importance that the indicator diagrams should be worked up as having no back pressure. As each diagram had some back pressure an average diagram from each test (determined by selecting a diagram having a mean effective pressure equal to the average) was taken and an exhaust line of no back pressure was plotted upon it. In order to know just how to plot this line, and the release and compression curves, a number of diagrams with different back pressures were taken from an engine (although of another make) having a stop-valve in the exhaust pipe. If the exhaust line was not quite correct it could not have been sufficiently erroneous to vitiate the results to any important extent.

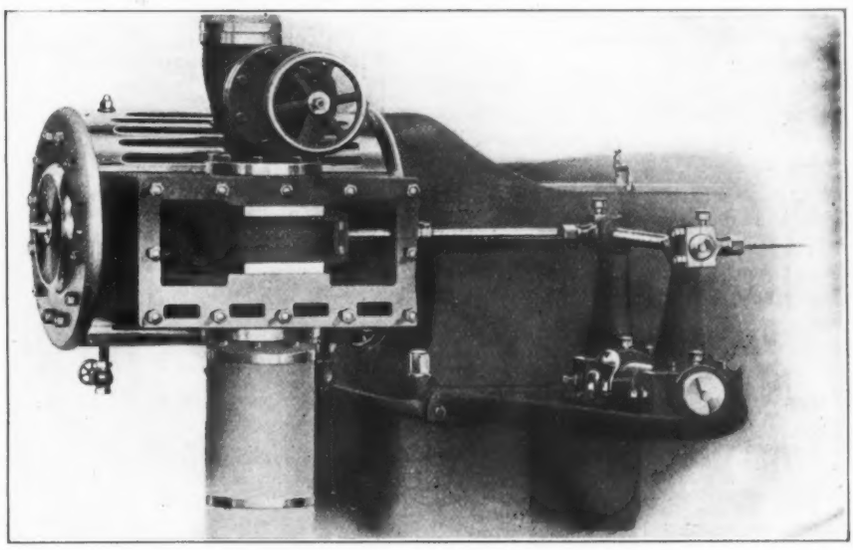


FIG. 3. SHOWING VALVE CHEST OF ENGINE NO. 3

Tests of Engine No. 2

This is a vertical engine having a valve and governor which are of the types described for engine No. 1, and to which that description applies.

It is direct-connected to two direct-current electric generators, the current of which is used for motors and for lighting. The work was too irregular for test purposes; therefore, a water rheostat for

RESULTS OF TESTS OF ENGINE NO. 3.

1.	Test No.	9	10
2.	Date	1907 Aug. 31	Sept. 3
3.	Previous length of service	28,644 hrs.	
4.	Size of cylinder	14 in. x 12 in.	
5.	Diameter of piston rod	1¾ in.	
6.	Generators	Two General Electric	
7.	Generator rating	Each 40 kw.–354 amp. 110 V.	
8.	Duration of tests	3 hr. 2 m.	3 hr.
9.	Approximate load	Full	¾
10.	Quality of steam	98.1	98.5
11.	Average steam pressure	90.8	91.1
12.	Average revolutions per minute	304.1	300.0
13.	Average temperature of room	95 deg.	98 deg.
14.	Average temperature of atmosphere	70 deg.	67 deg.
15.	Average barometer	14.70 in.	14.74 in.
16.	Indicator spring	60 lb.	60 lb.
17.	Indicated horse-power	124.4	79.13
18.	Indicated friction horse-power[1]	4.34	
19.	Indicated friction horse-power, per cent.	3.49	
20.	Indicated horse-power to atmospheric line	146.0	93.23
21.	Average back pressure	8.20	3.85
22.	Average cut off, per cent.	45.3	25.1
23.	Average kilowatt observed	69.1	44.0
24.	Average kilowatt to atmospheric line	81.4	51.7
25.	Efficiency e.h.p. to i.h.p., per cent.	74.3	73.9
26.	Total water consumed, pounds	14,166	8856
27.	Water consumed per hour, pounds	4670	2952
28.	Water per i.h.p. per hour, observed, pounds.	37.5	37.3
29.	Water per i.h.p. per hour to atmosphere, pounds	32.0	31.7
30.	Water per kilowatt per hour observed, pounds	67.6	67.1
31.	Water per kilowatt per hour to atmosphere, pounds	57.4	57.1

[1]Generator unexcited.

furnishing the load was made and the tests were carried on when the engine was not in regular service.

The water for making steam was weighed and pumped into two horizontal return-tubular boilers by a pump taking steam from a third boiler, this boiler being separated in all respects from the other two. The quality of the steam was determined by a Peabody calorimeter.

Tests of Engine No. 3

This is a horizontal engine direct-connected to two electric generators, and is used on power and lighting. As the load was irregular it was necessary to use a water rheostat.

The boilers were of the horizontal return-tubular type and weighed water was pumped into them.

This engine is equipped with a peculiar type of balanced valve. It slides between two seats, one on the top and one on the bottom of the steam chest, the ports being cast in the top and bottom of the chest and finally coming together and passing to the ends of the cylinder. The steam enters the inside of the valve and being admitted to both top and bottom ports simultaneously, the valve is, in effect, double ported. Similarly the exhaust comes from both top and bottom and the valve is, therefore, double ported on the exhaust. The valve is not a single piece without adjustment; the top and bottom are two separate pieces having circular backs, one fitting inside of the other and being packed with sprung rings. The valve is sufficiently unbalanced to keep the two parts against their respective seats with slight pressure, and they follow up any wear that takes place, and should keep tight under the circumstances of ordinary service. The engine is provided with a Rites governor.

Tests of Engine No. 4

This is a horizontal center-crank engine with four slide valves, two inlet valves on one side of the cylinder, one valve being on each end, and two exhaust valves similarly situated on the other side of the cylinder. Each valve slides between its seat and a balance plate and is perfectly balanced and double ported. Compensation for wear is provided by scraping the strips that maintain the balance plate at a fixed distance from the seat. The ports are direct and the clearance evidently small. The governor is of the Rites type, and acts on the inlet valves. The exhaust valves are operated by a fixed eccentric.

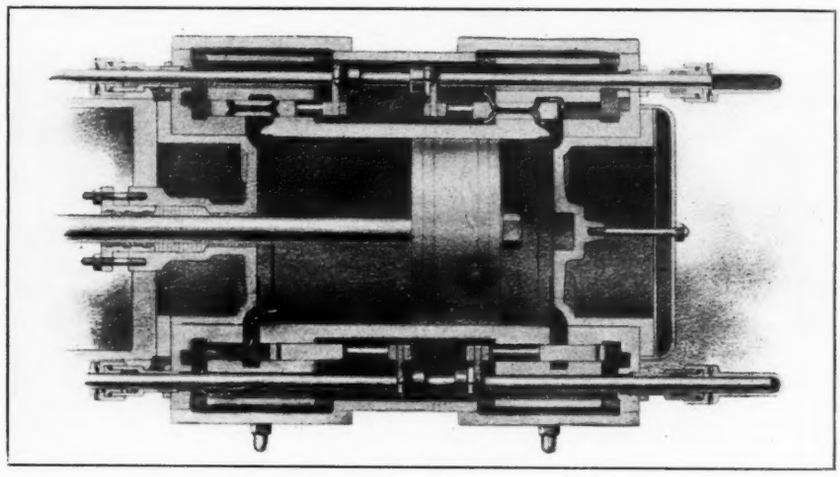


FIG. 4. SHOWING VALVE CHESTS OF ENGINE NO. 4

The engine is direct-connected to its generator.

The steam was condensed in a surface condenser of large size, and an abundant supply of circulating water was supplied. A cover over an opening on the condenser was removed in order to prevent a vacuum from being formed. The condenser was sufficiently high to permit the water formed by the condensation of the steam to run into either of two barrels, each resting on a platform scale where it was weighed. The condenser was tested for leaks, and found to be tight.

The steam from this engine was furnished by vertical fire-tube boilers and was somewhat superheated.

RESULTS OF TESTS OF ENGINE NO. 4.

1.	Test No.	1	2	3
2.	Date	1907 Aug. 2	Aug. 1	Aug. 2
3.	Previous length of service	719 hours		
4.	Size of cylinder	16.09 in. x 14 in.		
5.	Diameter of piston rod	2½ in.		
6.	Generator	Allis-Chalmers-Bullock		
7.	Generator rating	125 kw., 3 ph., 600 V. 120 amp.		
8.	Duration of tests, hours	3½	6	3½
9.	Approximate load	½	¾	Full
10.	Quality of steam—superheated	18 deg. F.	22 deg. F.	19 deg. F.
11.	Average steam pressure, pounds	113.3	116.6	113.9
12.	Average revolutions per minute	268.9	268.3	264.0
13.	Average temperature of steam	364 deg.	367 deg.	365 deg.
14.	Average temperature of room	85 deg.	88 deg.	89 deg.
15.	Average temperature of atmosphere	80 deg.	83 deg.	85 deg.
16.	Average barometer, inches	14.70	14.69	14.68
17.	Indicator spring, pounds	80	80	80
18.	Indicated horse-power	99.36	138.1	184.0
19.	Indicated friction horse-power[1]			9.70
20.	Indicated friction horse-power, per cent.			5.27
21.	Indicated horse-power to atmospheric line	114.7	159.7	214.0
22.	Average back pressure, pounds	3.5	5.1	8.3
23.	Average cut-off, per cent.	16.5	27.0	40.1
24.	Average kilowatts observed	63.1	94.3	124.3
25.	Average kilowatts to atmospheric line	76.0	109.3	143.3
26.	Efficiency e.h.p. to i.h.p. per cent.	84.7	91.0	90.0
27.	Total water consumed, pounds	15,900	35,987	27,465
28.	Water consumed per hour, pounds	4543	5998	7850
29.	Water per i.h.p. per hour observed, pounds	45.7	43.4	42.7
30.	Water per i.h.p. per hour to atmosphere, pounds	39.6	37.5	36.7
31.	Water per kilowatt-hour, observed, pounds	72.0	63.6	63.1
32.	Water per i.h.p. per hour to atmosphere, pounds	59.8	54.9	54.7

[1]Generator unexcited.

Tests of Engine No. 5

No. 5 was a vertical cross-compound condensing engine, in rather poor condition, judging from the noise made by it. It was provided with a surface condenser which leaked somewhat, but the leakage

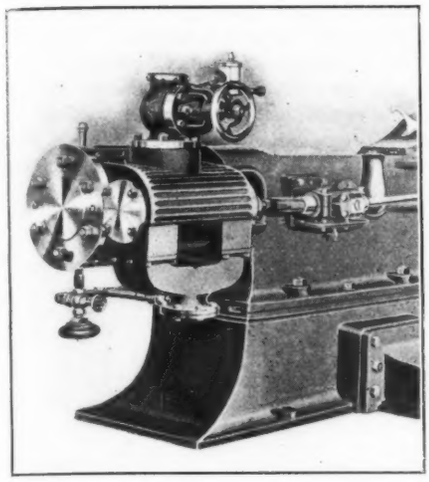


FIG. 6. SHOWING TYPE OF ENGINE "A"

rate was determined. While the accuracy of this test is not as great as is desirable, it will give some idea of the engine's performance. It is to be regretted that the results of the two tests are so dissimilar and we are unable to give any reason for this.

There are two piston valves for each cylinder, one being the cut-off riding inside of the inlet valve, and controlled by a shaft governor.

The steam consumption was determined by weighing the discharge from the condenser, and making proper allowance for the condenser leakage. This engine was direct-coupled to its electric generator.

Tests of Engine A

This is a side-crank, simple non-condensing engine direct-coupled to a direct-current generator. The load was carried by a water rheostat. The valve is an adjustable piston operating in removable bushings. The steam enters the center of the valve and exhausts at the ends. The governor is of the shaft type.

RESULTS OF TESTS OF ENGINE NO. 5.

1.	Test No.	11	12
2.	Date	1907 Sept. 8	Sept. 8
3.	Previous length of service	15,000 hrs.	
4.	Size of cylinder	$12\frac{3}{5}$ in. and $19\frac{1}{16}$ in. x 14 in.	
5.	Diameter piston rod	$2\frac{1}{5}$ in. and $2\frac{3}{4}$ in.	
6.	Generator	One General Electric	
7.	Generator rating	100 kw. d.c. 220-230 V.	
8.	Duration of tests, hours	3	2
9.	Approximate loads	8–10	7–10
10.	Quality of steam	99.2	99.3
11.	Average steam pressure, pounds	113.8	114.9
12.	Average revolutions per minute	229.8	231.5
13.	Average temperature of room	77 deg.	81 deg.
14.	Average temperature of atmosphere	70 deg.	66 deg.
15.	Average barometer	14.73 in.	14.75 in.
16.	Indicator springs	80 high	20 low
17.	Indicated horse-power	141.1	123.3
18.	Indicated friction horse-power[1]	10.2	
19.	Indicated friction horse-power, per cent.	7.2	
20.	Indicated horse-power to 26-inch vacuum	158.5	133.0
21.	Average cut-off horse-power cylinder	33	21
22.	Average cut-off l.p. cylinder	38	25
23.	Average kilowatts observed	83.1	70.9
24.	Average kilowatts to 26-inch vacuum	95.0	77.4
25.	Efficiency e.h.p. to i.h.p., per cent.	78.5	76.7
26.	Total water used, pounds	10,595	4951
27.	Water per hour, pounds	3532	2476
28.	Water per i.h.p. observed, pounds	25	20.1
29.	Water per i.h.p. to 26-inch vacuum, pounds	22.3	18.6
30.	Water per kilowatt hour observed, pounds	42.5	34.9
31.	Water per kilowatt hour to 26-inch vacuum, pounds	37.2	32.0
32.	Dry steam per i.h.p. hour to 26-inch vacuum, pounds	22.1	18.4
33.	Dry steam per kilowatt hour to 26-inch vacuum, pounds	36.8	31.8

[1]Generator unexcited.

The engine began service September 7, 1903, and the cylinder was rebored in 1906 and provided with a new piston. The condition of the engine was considered good, except for slight leakage of the valve. It had run about 32,000 hours, of which about 4300 hours were since reboring the cylinder.

Tests of Engine B

This is a center-crank engine; its piston valve has center admission and end exhaust and is double ported. The steam chest, although containing a piston valve, is shaped as for a flat valve, and has a bare circular bonnet on the side as well as one on the end. The engine is equipped with the H. C. Nichols governor.

This engine was installed in April, 1906, and has been in service about 5600 hours. A new valve was put into the engine a short time before the tests were made, and there were thereafter slight leaks of the valve and piston.

RESULTS OF TESTS OF ENGINE A.

1.	Test No.	1	2	3
2.	Date	November 11, 1907		
3.	Previous length of service	About 32,000 hrs.		
4.	Size of cylinder	$18\frac{1}{16}$ in. x 18 in.		
5.	Diameter of piston rod	3 in.		
6.	Generator	General Electric Co., d.c.		
7.	Generator rating	150 kw., 112 volts, 1339 amp.		
8.	Duration of tests	3 hr.	3 hr.	3 hr.
9.	Approximate load	1	$\frac{3}{4}$	$\frac{1}{4}$
10.	Average steam pressure, pounds	115.6	114	111.4
11.	Average revolutions per minute	221.7	221.9	222.8
12.	Indicated horse-power	273.8	170.8	122.4
13.	Indicated friction horse-power[1]	4.4		
14.	Indicated friction horse-power, per cent.	1.6		
15.	Average back pressure, pounds, in exhaust pipe	0.32	0.12	0.07
16.	Average amperes	1622	1020	703
17.	Average volts	114.3	112.1	112.0
18.	Average kilowatts	186.2	114.3	78.8
19.	Efficiency e.h.p. to i.h.p., per cent.	91.16	89.70	86.28
20.	Total water consumed, pounds	24,400	17,833	14,645
21.	Water consumed per hour, pounds	8133	5944	4882
22.	Water consumed per i.h.p. per hour observed, pounds	29.70	34.80	39.89
23.	Water consumed per i.h.p. per hour to atmosphere, pounds	29.53	34.67	39.75
24.	Water consumed per kilowatt-hour observed, pounds	43.68	52.00	61.95
25.	Water consumed per kilowatt-hour to atmosphere, pounds	43.42	51.80	61.76

[1]Generator unexcited.

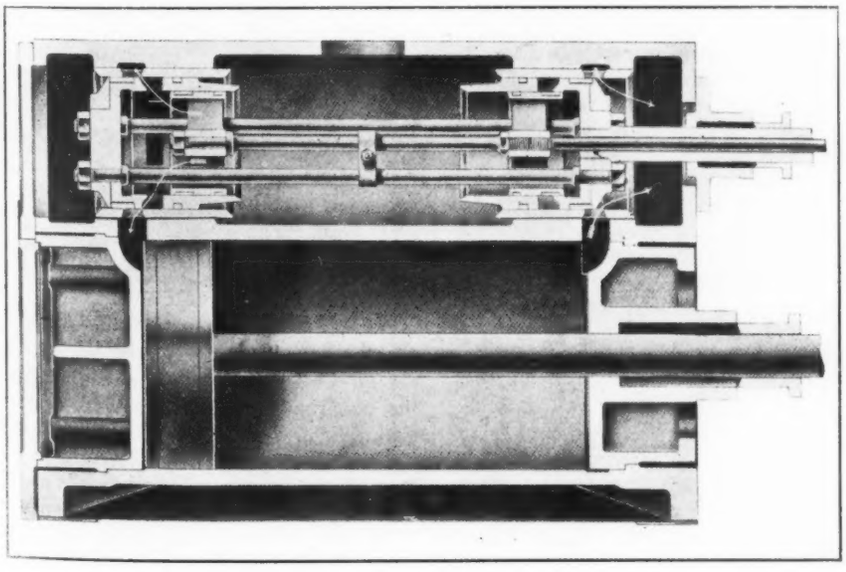


FIG. 5. SHOWING VALVE CHEST OF ENGINE NO. 5

Tests of Engine C

This is a side-crank, high-speed engine having four valves. The admission valves are on the side of the cylinder and are of the balanced type, sliding between the seat and a heavy balance plate. They are in effect double-ported and are almost exactly as already described for the inlet valves of engine No. 4, tested by Mr. Dean. There are no packing strips to prevent leakage, and tightness depends upon perfect workmanship and fitting. It is not expected that these valves will wear materially, if at all, but if they should, they, and the balance plates and distance

RESULTS OF TESTS OF ENGINE B.

	1	2	3	4
1. Test No.				
2. Date		Dec. 17, 1907		
3. Previous length of service		5600 hours		
4. Size of cylinder		15½ in. x 16 in.		
5. Diameter of piston rod		2⅞ in.		
6. Generator		Fort Wayne d.c.		
7. Generator rating		100 kw., 115 volts, 870 amp.		
8. Duration of tests, hours	3	3	3	3
9. Approximate load	Full	¾	½	¼
10. Average steam pressure, pounds	88.7	90.9	92.1	82.2
11. Average revolutions per minute	244.3	246.2	248.8	247.8
12. Indicated horse power observed, i.h.p.	137.6	102.9	69.3	36.2
13. Indicated friction horse-power[1]	7.2			
14. Indicated friction horse-power, per cent.	5.2			
15. Average back pressure in exhaust pipe, pound	0.62	0.52	0.74	0.82
16. Average amperes	836	593	377	168
17. Average voltage	111.6	114.1	114.1	112.7
18. Average kilowatts	93.3	67.7	43.1	18.9
19. Efficiency e.h.p. to i.h.p., per cent.	90.9	88.2	83.3	69.8
20. Total water consumed, pounds	14,080	11,419	8797	6118
21. Water consumed per hour, pounds	4693	3806	2932	2039
22. Water consumed per i.h.p. per hour observed, pounds	34.1	37.0	42.3	56.3
23. Water consumed per i.h.p. per hour to atmosphere, pounds	33.55	36.3	40.7	52.0
24. Water consumed per kilowatt-hour observed, pounds	50.3	56.2	68.1	107.9
25. Water consumed per kilowatt-hour to atmosphere, pounds	49.4	55.2	64.8	96.7

[1]Generator unexcited.

strips can be refitted. The exhaust valves are under the cylinder, are cylindrical, and are like many Corliss valves.

The governor is of the shaft type and does not differ materially from others. The centrifugal force of the weights is balanced by a flat leaf spring.

This engine began service on February 22, 1904, and has run about 13,000 hours. No repairs have been made, and it is thought that the engine is not in the best condition.

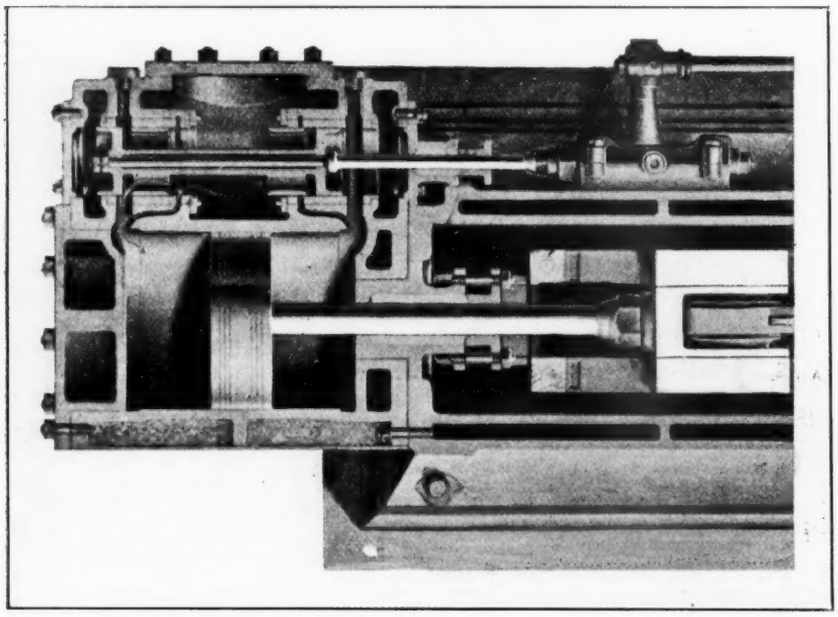


FIG. 7. SHOWING VALVE CHEST OF ENGINE "B"

RESULTS OF TESTS OF ENGINE C.

	1	2	3
1. Test No.			
2. Date		Dec. 28, 1907	
3. Previous length of service		10,800 hours	
4. Size of cylinder		12 in. x 18 in.	
5. Diameter of piston rod		2¼ in.	
6. Generator		Quaker City d.c.	
7. Generator rating		75 kw., 250 volts, 300 amp.	
8. Duration of tests, hours	2½	3	3½
9. Approximate loads	50 per cent. overload	Full	½
10. Average steam pressure, pounds	90.2	86.3	90.4
11. Average revolutions per minute	186.4	188.0	189.0
12. Indicated horse power observed, i.h.p.	111.3	74.2	43.0
13. Average friction horse-power[1]		7.1	
14. Average friction horse-power, per cent.		9.5	
15. Average back pressure in exhaust pipe, pounds	0.20	0.08	0.00
16. Average amperes	308.5	198.2	105.5
17. Average voltage	228.2	227.5	226.5
18. Average kilowatts	70.40	45.15	23.89
19. Efficiency e.h.p. to i.h.p., per cent.	84.8	81.7	74.5
20. Total water consumed, pounds	9496	8200	6626
21. Water consumed per hour, pounds	3796	2733	1893
22. Water consumed per i.h.p. per hour observed, pounds	34.10	36.80	44.02
23. Water consumed per i.h.p. per hour to atmosphere, pounds	34.00	36.73	44.02
24. Water consumed per kilowatt-hour observed, pounds	53.92	60.60	79.30
25. Water consumed per kilowatt-hour to atmosphere, pounds	53.74	60.48	79.30

[1]Generator unexcited.

Conclusions

The accompanying tables show the economical results of the tests of the non-condensing engines. The most important feature in these results is that the four-valve engines, which were built to be more economical than single-valve engines, have utterly failed in their object. No. 4 engine had steam superheated some 20 degrees Fahrenheit, and this gave the engine a great advantage over any other tested. These results show that efforts

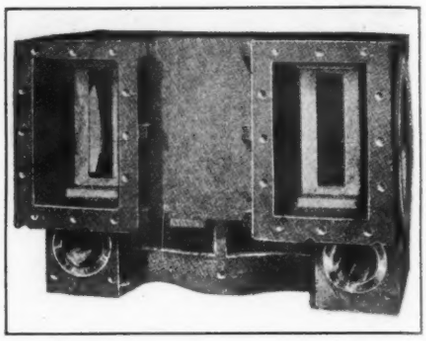


FIG. 8. VALVE SEATS, ENGINE "C"

to realize economy by duplication, or multiplication, of parts, even if ports are shortened and clearances reduced, accomplish nothing. The duplication of valves used in both four-valve engines simply increased the opportunity for leakage. In engine C the exhaust valves probably were tight, and as far as possible minimized the effect of the probable very large leakage by the inlet valves.

After considering these tests, we do not hesitate to advise builders to abandon four valves for high-speed engines unless they are prepared to build a really high-class engine having four Corliss or grid-iron valves, made and fitted in the best manner. Even then it would be necessary for them to prove their case. Steam engines of whatever type should have valves that are not only tight originally, but that

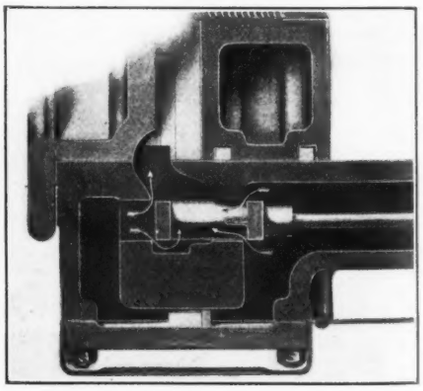


FIG. 9. ADMISSION VALVE, ENGINE "C"

should become so by wear if they are not so originally. The wearing process should be a tightening process.

Comparing the results of the flat-valve engines, the most economical results were obtained from engine No. 3, having a valve which automatically takes up wear, and, if it does not cut, must maintain itself tight for long periods. The valve of this

engine is evidently its saving feature, for the port system could hardly be worse for realizing economy. The ports are long and tortuous, and have great surface, and the clearance volume must be large.

Comparing the piston-valve engines, there is little reason for one being superior to the other, although engine A surpassed engine B in economy. Engine B has considerable unprotected surface on the steam chest, and this must increase condensation.

Comparing the flat and piston-valve engines, if we do not consider the loads, the most economical result was obtained from a piston-valve engine. This result however, was obtained when the engine was heavily loaded. With the lighter loads that are comparable the flat-valve engine No. 3 surpassed engine A in economy. Moreover, the flat-valve engines give a flatter load curve than the piston-valve engines, which is a valuable feature.

Engine.	Duration of Service.	Steam Used per Hour to Atmosphere at ¼ Load.	½ Load.	¾ Load.	Full Load.	1¼ Load.	1½ Load.
	Hrs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
No. 1 One Flat Valve	15,216		38.5 per i.h.p. 37.2 per i.h.p. 62.3 per kw.-hr 60.2 per kw.-hr.	36.2 per i.h.p. 58.4 per kw.			
No. 2 One Flat Valve	20,000		36.7 per i.h.p. 66.0 per kw.-hr.		35.8 per i.h.p. 59.7 per kw.-hr.		
No. 3 One Flat Valve	28,644		31.7 per i.h.p. 57.1 per kw.-hr.		32.0 per i.h.p. 57.4 per kw.-hr.		
No. 4 Four Flat Valves	719		39.6 per i.h.p. 59.8 per kw.-hr.	37.5 per i.h.p. 54.9 per kw.-hr.	36.7 per i.h.p. 54.7 per kw.-hr.		
A One Piston Valve	32,000		39.75 per i.h.p. 61.76 per kw.-hr.	34.67 per i.h.p. 51.80 per kw.-hr.		kw.-hr. 29.53 per i.h.p. 43.42 per kw.-hr.	
B One Piston Valve	5600	52.0 per i.h.p. 96.7 per kw.-hr.	40.7 per i.h.p. 64.8 per kw.-hr.	36.3 per i.h.p. 55.2 per kw.-hr.	33.55 per i.h.p. 49.4 per kw.-hr.		
C Two Flat Inlet Valves Two-rotating exh. valves	10,800		44.02 per i.h.p. 79.30 per kw.-hr.		36.7 per i.h.p. 60.48 per kw.-hr.		34.10 per i.h.p. 53.74 per kw.-hr.

The performances of the perfectly balanced flat-valve engines are so relatively poor, that it seems to disqualify them, unless this type of valve can be made with some mechanism by which wear will not increase leakage. Possibly metal strips might be used in a manner similar to that employed in the Richardson valve. It must be difficult to keep a shop force up to the pitch required to fit these valves, balance plates, and distance strips properly. It is doubtful, in fact, if this type of valve is tight even when new, and it has no chance of ever being tight thereafter unless it is refitted, which is seldom done. This type of valve must take the whole responsibility of the extravagance of the four-valve engines. Engine No. 1 had the advantage of steam superheated 7 degrees Fahrenheit to 14 degrees Fahrenheit.

The results show that heavy loads with high-speed engines give the most economical results, and this confirms the statement of D. K. Clark in the early fifties that the most economical point of cut-off in locomotives is at about one-third stroke. This was again substantiated by Professor Goss with the experimental locomotive at Purdue University.

One interesting thing about the results is that no stationary high-speed engine is as economical as passenger locomotives that are in good order. We expect that such locomotives will use as little as 26 pounds of steam per indicated horsepower per hour, and better results have been obtained. This economy was realized before very high steam pressures were used.

It is unfortunate that the tests were not of greater duration, but the results would probably not have been thereby materially different.

In regard to the relative economies of flat and piston-valve engines, we are inclined to believe that the former are the more economical, if the valves are self-adjusting with wear, and are of a good design. They must have less port surface and less clearance, and can be made to adjust themselves for more wear than piston valves.

Persons who are familiar with guarantees of steam consumption which accompany sales of high-speed engines are aware that these guarantees are usually met in shop tests, but the present tests show that no engine realized economies which would have been guaranteed. From the results we are justified in thinking that most high-speed engines rapidly deteriorate in economy. On the contrary, slower running Corliss or gridiron-valve engines improve in economy for some time and then maintain the economy for many years. It is difficult to see that the speed is the cause of this, and it must depend on the nature of the valve.

Discussion

C. A. Dawley thought the tests were interesting as isolated examples, but too general conclusions must not be drawn from them. It seemed to him especially rash to conclude that a reduction of the clearance space shortening the ports, and compression to fill the admission and exhaust passages, accomplished nothing merely because the two engines in these tests which were so arranged, were fitted with pressure-plate balanced valves, which leaked. The fact that the four-valve engines tested were fitted with leaky valves should not be used as an argument against four-valve engines. The poor results obtained with the tests under consideration are attributed by the author largely to valve leakage, but piston leakage is equally important. Tests made by the speaker, of leakage in air-compressor cylinders, showed leakages of from 5 to 15 per cent. of the piston displacement.

R. C. Stevens described a valve which the builders would guarantee to remain tight without attention for five years. It was balanced by a ring bearing upon the steam-chest cover, and was equivalent to 80 per cent. of the valve area, leaving the pressure upon 20 per cent. to keep the valve to its seat. The speaker had examined engines fitted with these valves after having been run in one case thirteen and in another seventeen years, and found them in perfect condition, without having been refitted.

F. W. Salmon submitted eight diagrams, in which he had plotted from all the available data the steam consumption against the mean effective pressure, to the end that he could select the most economical load in mean effective pressure for the conditions of a test, or choose an engine suitable for a given service.

George H. Barrus said that the paper conformed to his experience in the matter of valve leakage. It would have added to the value of the paper if it had included one or two engines having single-piston valves with ring packing, in which the wear takes itself up automatically. He had tested many of these engines for leaks after having been in service for a year or more, and did not recall a single instance where leakage of any account was revealed.

Air Leakage in Steam Condensers*

Ability to Handle Air as Important as That to Condense Water; Formulas and Charts for Computing the Amount of Air Present

BY THOMAS C. M'BRIDE

Experience has shown that the presence of a small amount of air in a steam condenser has a marked effect upon its capacity and efficiency. In spite of this no serious attempt seems to have been made to determine quantitatively the amount of air mixed with steam in ordinary practice, nor definitely to define or limit this amount to exact figures in condenser contracts and guarantees.

If it can be demonstrated that the greater part of the air coming to condensers is the result of air leaks, and that these leaks are mostly in the prime mover and its connections and likely to be but small in amount in the condenser itself; and if it is possible to devise some convenient method of estimating the proportions of the air to the exhaust steam required to be handled by the condenser, then it is only as fair to expect that purchasers' specifications shall at least limit the amount of air to be handled by the air pump, that the manufacturer may intelligently select the size of this pump, as it is to expect these specifications to state the amount of steam to be condensed, that the manufacturer may properly determine the size of the condenser.

In view of the one-sidedness of the usual purchaser's specifications in this regard, it is not surprising to find the manufacturer in turn stipulating that the prime mover and its piping shall be "free from air leaks" and then furnishing an air pump costing a very appreciable fraction of the total plant cost to remove air specified not to be present.

The author believes and assumes that the amounts of air passing through different condensers may be best measured and compared on the basis of the relation of the volume of this air to the volume of the steam being condensed, both being at the pressure and temperature existing in the particular exhaust pipe. The most convenient unit of volume is the volume of the water of condensation coming from the steam. The ratio of the volume of air passing through the air pump to the volume of water of condensation is then used to measure the air.

The most reliable index of the proportion of air to exhaust steam customary in existing plants is to be found in the ratings of air pump capacity in general use. Manufacturers of vertical twin air pumps and surface condensers usually guarantee them from 26 inches vacuum (30 inches barometer) and 110 degrees Fahrenheit, hot-well temperature, with 70 degrees injection and 110 degrees discharge temperature, under which conditions it is customary to furnish an air pump of a displacement about thirteen times the volume of the water condensed.

Presuming that the friction of the vapors in passing through the condenser is negligible and that the volumetric efficiency of this type of air pump is the same for the air as for the water, this rating presumes that for every unit volume of water of condensation there will be present in the air-pump suction pipe twelve volumes of air, saturated at 26 inches and 110 degrees, at which temperature the pressure of the steam alone is 2.58 inches absolute.

The twelve volumes of saturated air in the air-pump suction pipe is made up (Dalton's law*) of

	Inches Absolute.
12 volumes of steam at	2.58
12 volumes of air at	1.42
Total pressure,	4.00

Reduced to the condition in the exhaust pipe, that its volume may be comparable to the volume of the exhaust steam, this air alone becomes:

$$12 \times \frac{1.42}{4} \times \frac{459.5 + 125}{459.5 + 110} = 4.37$$

volumes.

The unit volume of water passing through the air pump with this air was, before condensation 11,000 times its volume. The proportion of air to 10,000 volumes of exhaust steam is, therefore,

$$\frac{4.37 \times 10{,}000}{11{,}000} = 4.0$$

volumes.

This amount, four volumes of air per 10,000 volumes of steam, represents the upper limit of the proportion of air to exhaust steam anticipated by American practice in air-pump guarantees for the class of steam plant usually supplied with vertical twin air pumps, as indicated by the success of large numbers of these pumps in achieving their rated results.

Horizontal air pumps for 26 inches vacuum and 110 degrees hot-well temperature are rated by most manufacturers as having a displacement of about 20 times the volume of the water of condensation. This rating presumes the presence of air in the proportion of 6.3 volumes to 10,000 volumes of exhaust steam.

Air pumps for jet condensers for 70 degrees injection and 26 inches vacuum, on the presumption that the discharge temperature will be 110 degrees, are usually rated at a displacement of 52 times the volume of the water of condensation. On these presumptions, this displacement will be made up of:

	Volumes.
Condensed steam	1.0
Air entering with steam through boiler	0.3
Condensing water	26.0
Air entering with condensing water.	10.5
Air entering by leakage	14.2
Total	52.0

Figuring as above, 14.2 volumes of air in the air-pump suction at 4 inches absolute and 110 degrees were, before condensation, 4.7 volumes per 10,000 volumes of exhaust steam, or to refer to the basis used before for the surface condenser, the air entering by leakage and in the boiler feed aggregates 14.5 volumes and corresponds to 4.8 volumes per 10,000 volumes of exhaust steam.

Here, then, are three different amounts, 4, 6.3, and 4.8 volumes of air per 10,000 volumes of exhaust steam, which the custom of air-pump guarantees establishes as the limiting proportions of air to exhaust steam in usual practice. The first of these values seems most reliable because of the high volumetric efficiency of the vertical twin air pump, but as this type of pump is most often used in steam plants which, from their nature, are likely to have less leakage than the average plant, it is probable that 4 volumes is a little below the average. Neither of the other two values is likely to be as reliable as the first from the nature of the assumptions necessary in their deduction. It is, therefore, safe to say that provision to handle about 4.5 volumes of air per 10,000 volumes of exhaust steam at 26 inches is ample in steam-engine practice, and that more air than this indicates excessive leakage; this, however, depending somewhat on the size and type of plant.

Of the air that must be removed from the surface condenser, part enters with the steam through the boiler from the feed-water, the balance through leaks. If it be presumed that, as an outside figure, the feed-water contains 1/20 of its volume

*Abstract of a paper read at the Detroit meeting of the American Society of Mechanical Engineers, June 23 to 26, 1908.

*Dalton's law as it relates to steam in condensers was explained by the author in a paper delivered before the Engineers' Club of Philadelphia.

of air under atmospheric conditions and is at 70 degrees Fahrenheit, its relative volume, when it reaches the exhaust pipe entering the condenser, will be:

$$\frac{1}{20} \times \frac{459.5 + 125}{459\ 5 + 70} \times \frac{30}{4} \times \frac{10{,}000}{11{,}000} = 0.38$$

volume per 10,000 volumes of exhaust steam; or if the feed be heated to 210 degrees before being pumped into the boiler:

$$\frac{1}{20} \times \frac{459\ 5 + 125}{459\ 5 + 210} \times \frac{30}{4} \times \frac{10{,}000}{11{,}000} = 0.33$$

volumes per 10,000 volumes exhaust.

This shows that of the air-pump capacity presumed necessary by manufacturers, about 7 to 9 per cent. is required to handle the air coming into the condenser with the feed-water and that the balance is required to remove the air entering by leakage and is largely an unnecessary expenditure. Certainly, then, the responsibility for limiting the amount of air is with the prime mover and its piping, and it is only reasonable to expect those controlling these features of the plant to indicate the amount of air the pump must handle and not to compel the condenser manufacturer to guess at it.

There seems to be no other means of measuring the air coming to any condenser than by the displacement of its air pump. The proportion of air mixed with the exhaust steam is so small that the temperature drop due to its presence could not be used. Thus, 4 volumes of air per 10,000 volumes of exhaust steam would cause a lowering of the temperature below that due to the pressure, of 0.014 degree Fahrenheit at 28 inches vacuum, and 0.015 degree at 26 inches vacuum.

Charts have been prepared to simplify the calculations necessary to determine the proportions of air and exhaust steam passing into the condenser, after the ratio of volume of water of condensation to volume of air passing through the air pump, and the temperature of this air, have been determined. The curves of the charts, Figs. 1 and 2, show the relations of these quantities. There are three sets of these curves in Fig. 1, for three vacua; the abscissas are volumes of air added to 10,000 volumes of steam and the ordinates are ratios of the volumes of this air saturated at the temperatures marked on each curve to the volume of the water of condensation. Thus, the curve marked 26 inches and 110 degrees Fahrenheit, shows that an air-pump displacement ratio of 12 volumes of air to 1 of water should, at this temperature and pressure, correspond to a mixture of 4 volumes of air and 10,000 volumes of steam at this same pressure, before condensation agreeing with previous calculation.

These curves are purely theoretical, and can be used for any type of condenser to determine the ratio after condensation of the volume of air and water at certain temperatures which correspond to certain proportions of air mixed with the exhaust steam passing to the condenser and can, therefore, be used for selecting both dry air-pump sizes and wet air-pump sizes where hot-well temperatures are to be guaranteed and where the proportion of air to exhaust steam is either specified or assumed.

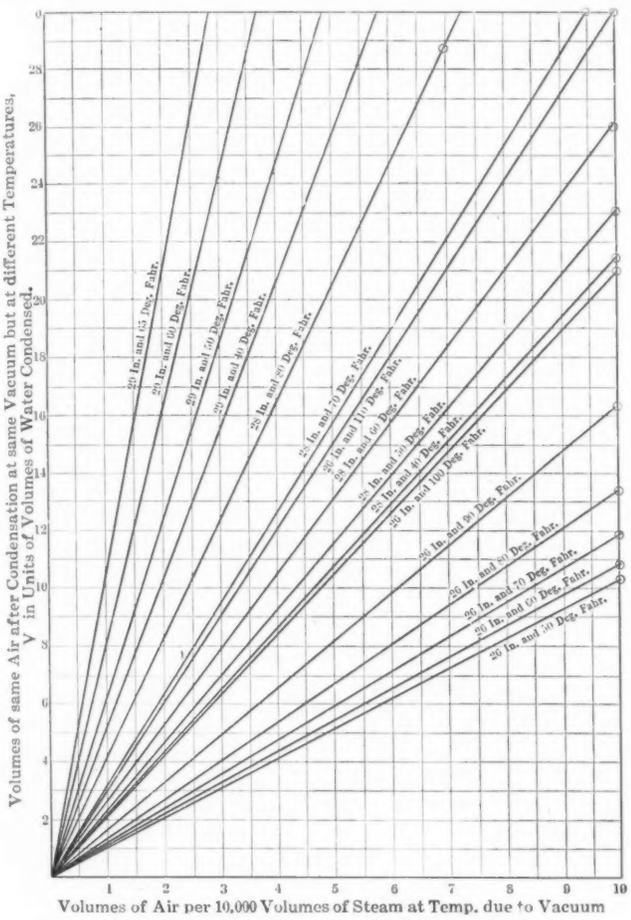

Volumes of same Air after Condensation at same Vacuum but at different Temperatures, V in Units of Volumes of Water Condensed.
Volumes of Air per 10,000 Volumes of Steam at Temp. due to Vacuum
29 In. and 105 Deg. Fahr.
29 In. and 90 Deg. Fahr.
29 In. and 80 Deg. Fahr.
29 In. and 70 Deg. Fahr.
29 In. and 60 Deg. Fahr.
28 In. and 110 Deg. Fahr.
28 In. and 100 Deg. Fahr.
28 In. and 90 Deg. Fahr.
28 In. and 80 Deg. Fahr.
28 In. and 70 Deg. Fahr.
28 In. and 60 Deg. Fahr.
27 In. and 90 Deg. Fahr.
27 In. and 80 Deg. Fahr.
27 In. and 70 Deg. Fahr.
27 In. and 60 Deg. Fahr.
26 In. and 80 Deg. Fahr.
26 In. and 70 Deg. Fahr.
26 In. and 60 Deg. Fahr.
26 In. and 50 Deg. Fahr.

FIG. 1. CURVES BASED ON 30-INCH BAROMETER

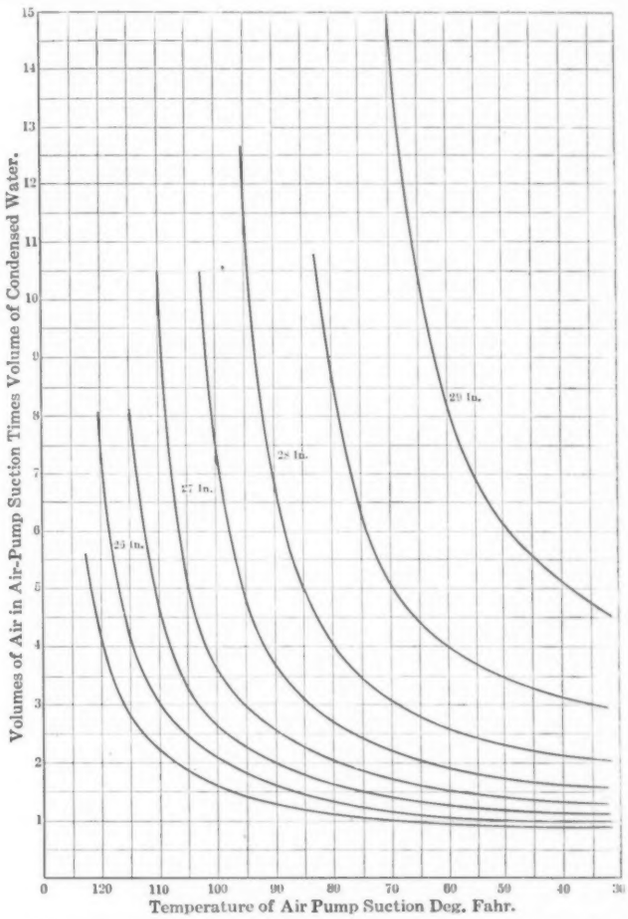

Volumes of Air in Air-Pump Suction Times Volume of Condensed Water.
Temperature of Air Pump Suction Deg. Fahr.
29 In.
28 In.
27 In.
26 In.

FIG. 2. RESULTING VOLUME IN AIR PUMP SUCTION DUE TO PRESENCE OF 1/10,000 PART BY VOLUME OF AIR IN EXHAUST STEAM

The curves also show the great influence of air-pump suction temperature on the capacity of an air pump to handle air. Thus an air pump with 4 inches absolute pressure can handle about twice the amount of air at 90 degrees it could handle at 110 degrees, and at 40 degrees about three times its capacity at 110 degrees. This feature of the curves also shows quantitatively the benefit gained in reduction of volume of air by the "dry" system, using a rotative dry-vacuum pump. Without sacrifice of hot-well temperature, this system removes the air near or at the temperature of the injection. If used on the presumed conditions of the vertical twin pump first mentioned, 12

volumes of air at 4 inches absolute and 110 degrees would be cooled to 70 degrees and become

$$12 \times \frac{459.5 \times 70}{459.5 \times 110} \times \frac{1.42}{3.27} = 4.85$$

volumes.

Referring to the curves it is seen that 12 volumes of air and 1 volume water at 4 inches absolute and 110 degrees and 4.85 volumes air and 1 volume water at 4 inches absolute and 70 degrees were each 4 volumes of air and 10,000 volumes of steam (both at 26 inches and 125 degrees) before condensation.

The curves also show, although not accurately, the fallacy of the short rule so often used which presumes that halving the absolute pressure will double the volume of air to be handled. As a matter of fact, the volume will be increased much more than twice if there is no accompanying temperature change and at least twice unless there is a very considerable accompanying temperature reduction.

As an example: Suppose a certain volume of air saturated at 70 degrees Fahrenheit (steam at 0.73 inch absolute) and 4 inches absolute, a usual condition in the suction pipe of a rotative dry-vacuum pump when maintaining this vacuum. This air has a pressure of itself of 3.27 inches absolute. If this volume be expanded to half the pressure and the air be still kept saturated at 70 degrees, the air pressure itself will be 2 inches $-$ 0.73 inch $=$ 1.27 inches, and its new volume will be

$$\frac{4 - 0.73}{2 - 0.73} = \frac{3.27}{1.27},$$

or 2.57 times the original volume.

The actual conditions may be represented thus:

One vol. saturated air at 70 deg. and 4 in. abs. $=$ { One vol. air at 70 deg. and 3.27 in. abs. ; One vol. steam at 70 deg. and 0.73 in. abs. }

and becomes at 70 degrees and 2 inches absolute.

2.57 vols. saturated air at 70 deg. and 2 in. $=$ { 2.57 vols. air at 70 deg. and 1.27 in. abs. ; 2.57 vols. steam at 70 deg. and 0.73 in. abs. }

If, however, in halving the pressure it is also cooled to 50 degrees Fahrenheit (0.36 inch absolute) the new volume will be

$$1 \times \frac{459.5 + 50}{459.5 + 70} \times \frac{4 - 0.73}{2 - 0.36} = 1.92$$

times the original volume.

Similarly, a certain amount of air saturated at 70 degrees (0.73 inch absolute) and 28 inches becomes at 70 degrees and 29 inches

$$\frac{2 - 0.73}{1 - 0.73} = 4.7$$

times original volume; or at 50 degrees (0.36 inch absolute) becomes

$$1 \times \frac{459.5 + 50}{459.5 + 70} \times \frac{2 - 0.73}{1 - 0.36} = 1.91$$

times the original volume.

All of these results are shown with fair accuracy (within 5 per cent.) on the curves, although the curves in the set for each particular vacuum were intended to be referred only to other curves in the same set and not to curves for any other vacuum.

one a little above and one a little below nominal rating of the turbine and show from Table 1 that the air leakage in the turbine, piping and condenser based on ratio to volume of exhaust steam was about four times the largest amount customary in steam-engine practice. Tests 3 and 4 not only show enormous leakage, but also that the total amount of air increased as the load on the turbine decreased; a usual condition in steam turbines.

TABLE 1.

RESULTS OF FOUR TESTS ON LARGE SURFACE CONDENSER.

Test Number.	1	2	3	4
Ratio steam being condensed to guaranteed capacity of condenser for 70 deg. water and 28. in. vacuum, per cent	74	67	38	27.5
Vacuum in exhaust, 30 in. barometer, inches	28.03	28.18	28.28	27.34
Corresponding temperature, degrees F	101.0	97.8	95.9	109.4
Volumes exhaust steam times volume water of condensation	21,200	23,100	24,600	16,000
Steam condensed per square foot, pounds	5.62	5.1	2.85	2.07
Vacuum pump suction temperature, degrees F	56.7	58	58	56.2
Equivalent steam pressure, inches, abs	0.46	0.48	0.48	0.45
Air by volume in vacuum pump suction, per cent	76.5	73.7	72.2	83.4
Vacuum pump displacement times volume water of condensation	52.6	58.0	105.0	143.5
The same with 90 per cent. volumetric efficiency assumed	47.3	52.2	94.5	129.1
Volume air reduced to temperature and pressure in exhaust pipe times volume water of condensation	39.6	40.7	73.3	118.0
Volumes air in exhaust steam per 10,000 volumes exhaust steam	18.7	17.6	29.8	73.7

If then, it be decided, say, that 4.5 volumes of air per 10,000 volumes of exhaust steam shall be the permissible amount of air mixed with the exhaust steam in surface or jet condensers, the curves will show the volume of this air and consequently the effective vacuum-pump capacity required for it for each vacuum and each air-pump suction temperature. In the case of the jet condenser due allowance must be made for the air carried in by the injection water, an amount that can be predicted with a fair degree of accuracy provided, of course, the water be taken from a quiet pool.

As an example of conditions often found, the results of four carefully conducted tests of a very large surface condenser on a steam turbine are shown in Table 1. Tests Nos. 1 and 2 were made

It is interesting to note the effect of the large proportion of air mixed with the steam, particularly in the bottom of the condenser, on the heat-transferring capacity of the surface, as shown in Table 2. Certain of the steam-temperature readings of the test were liable to error through the impossibility of knowing surely that the thermometers were not influenced by water dripping on them from the colder tubes, so all of these and the values derived from them are marked (?). However, as these readings are the average of readings taken in two different parts of the condenser in each case they cannot be far wrong.

It is very evident from these tests that the middle and bottom nests of tubes

TABLE 2.

RESULTS SHOWING EFFECTS OF AIR MIXED WITH STEAM.

Test.	Nest of Tubes.	Steam Temperatures.			Water Temperatures.			Difference Temperatures Inside and Outside of Tubes. (?)	Steam Condensed per Sq.Ft. per Hour.	B.t.u. per Hour per Sq.Ft.	B.t.u. per Hr. per Sq.Ft. per Degree Difference. (?)	Air in Steam by Volume Per Cent. (?)
		Entering. (?)	Leaving. (?)	Average. (?)	Entering.	Leaving.	Average.					
1	top	101.0	91.1	96.0	56.0	66.0	61.0	35.0	12.03	13020	372	6.0
	middle	91.1	63.6	77.3	53.0	56.0	54.5	22.8	3.60	3888	171	51.0
	bottom	63.6	55.3	59.4	52.0	53.0	52.5	6.9	1.20	1296	189	75.0
2	top	97.8	91.7	94.8	56.0	66.0	61.0	33.8	10.89	11760	348	14.8
	middle	91.7	62.0	76.8	53.0	56.0	54.5	22.3	3.24	3498	156	47.0
	bottom	62.0	56.0	59.0	52.0	53.0	52.5	6.5	1.08	1164	180	73.0
3	top	96.0	89.3	92.6	54.0	60.0	57.0	35.6	6.12	6609	186	14.0
	middle	89.3	59.4	74.3	53.0	54.0	53.5	20.8	1.02	1101	54	47.0
	bottom	59.4	55.6	57.5	51.6	53.0	52.3	5.2	1.44	1554	30	72.0
4	top	109.4	100.0	104.7	54.0	57.5	55.7	49.0	2.64	2851	58	16.0
	middle	100.0	62.0	81.0	54.0	54.0	54.0	27.0				38.0
	bottom	62.0	54.4	58.2	52.0	54.0	53.0	5.2	1.50	1620	31	82.0

are doing practically no work and that the reason for this is the large proportion of air in the steam surrounding them as is shown approximately by the last column of Table 2. The heating of the circulating water being largely prevented in all but the top nest of tubes, the efficiency of the circulating system is very low even at the larger loads; 14 out of a possible 46 degrees in one case and 14 out of a possible 42 degrees in another.

It is of interest to consider what must be done to improve the vacuum in this condenser. From the fact that the air-pump suction temperature in these four tests was within 4.7, 6, 6.4 and 4.2 degrees, respectively, of the injection temperature, it is inferred that the condenser is doing fairly well as an instrument for cooling, especially in view of the large proportion of air present. The fault can then be corrected only by decreasing the amount of air in the condenser either by taking care of the air leaks or by increasing the speed or size of the air pump.

To reduce the air in the condenser to the equivalent of 4.5 volumes in the exhaust pipe to 10,000 volumes of exhaust steam, would require that the air leaks shown in the four tests be reduced to 24, 25.5, 15.1 and 6.1 per cent., respectively, of their present values, or that the speed or capacity of the air pump be increased about four times at full load on the turbine, about 6.5 times at half load and about 16 times at three-eighths load. The full benefit that would result from this change is hard to calculate, as it affects so many different features of the condenser. The first effect would be to reduce to one-quarter the proportion of air in the air-pump suction pipe. As there is an ample amount of cooling effect, this change would not materially affect the air-pump suction temperature.

The curves show that with 70 degrees injection temperature, presuming that the air-pump suction temperature could not be more than 75 degrees, the vacuum with same load and same air leakage as Test 1 would be 2.5 inches and with the leakage usual with steam engines would be equal to 1.3 inches. This excessive leakage was, therefore, causing a winter vacuum of 28.03 that ought to have been at least 29.1 inches and was likely to cause a summer vacuum of only 27.5 inches where it should have been at least 28.7 inches. The winter loss of fuel, due to the excessive leakage of this unit, averaged probably half a ton per hour.

It is to be regretted that there is not more information available on which exact estimates of air leakage can be made. There are turbine plants comparable in size with the plant cited above, in which the air leakage is less than we have assumed as the maximum allowable amount in steam-engine practice. One carefully conducted turbine test, which, however, did not include readings of air-pump suction temperature, shows that there could not have been more than about one-half of the maximum customary air leakage of steam-engine practice at a little below full load and a little above full load, respectively, on a steam turbine of the same size as the one tested with the results shown in Tables 1 and 2.

One of these condensers was handling eight times as much air as the other. Presuming that the same precedents were used in designing both, if one did not have too little area for the passage of the steam and a consequent friction loss, then the other had entirely too low a steam velocity and consequent low heat-transfer capacity of the surface and low efficiency of the condenser. Until the quantity of air to be handled by condensers with the steam is agreed upon in advance, condensers will continue to be designed from precedents based on obtaining guarantees even if the plants later develop to be quite leaky; high efficiency cannot therefore be expected even if the air leakage turns out later to be very low.

It must be evident that comparisons of results obtained in different plants and from different types of condensers cannot possibly be trustworthy unless the proportion of air for each case has been determined and due allowance made therefor. The amount of air present exerts a great influence on the relation between temperature and vacuum in the condenser; on the air-removing capacity of the air pump, and on the heat-transferring capacity of the surface or spray. The plant having the smallest air leakage might have an advantage sufficient to wipe out entirely the benefits that might be gained by any refinements in the design of condensers under comparison. Thus, a comparison between the condenser whose test is shown in Tables 1 and 2, having a cooler lowering the air-pump suction temperature almost to the circulating inlet temperature, and the unit mentioned later, with its cooler removed, the results of the two tests would have favored the latter, and it might have been concluded that cooling was of no benefit. The methods of measuring and comparing air leakages suggested in this paper would not only show this to be an erroneous conclusion and that air cooling was of great benefit to the unit, but it would also show the amount to be gained by such cooling.

The suggested measurement of the air coming to condensers necessitates the following readings:

1. Pressure in air-pump suction.
2. Temperature of air-pump suction.
3. Quantity of steam being condensed.
4. Effective vacuum-pump displacement.

For ordinary work and with properly built condensers, the vacuum in the condenser could be taken for the first reading, but for exact work the pressure and temperature should both be taken at the same point in the suction pipe. Determination of the effective vacuum pump displacement requires readings of the speed of the vacuum pump and an estimate of its volumetric efficiency from its indicator card. For barometric condensers and jet condensers with air pumps, certain allowances have to be made, requiring for their determination some previous practice with condensers of other types.

Discussion

Charles A. Howard suggested that the condenser man be given the contract for the exhaust piping, which would put him in control of the leakage.

In the steam turbine of the Parsons or Fullagar type, this leakage is immaterial. In the Curtis it is frequently excessive at light loads, but the guarantee is generally asked for at full load or over, so that this is immaterial. At full load these machines are nearly as tight as the horizontal type, and will hold over 29 inches referred to a 30-inch barometer when running full load, with a ratio of vacuum-pump displacement of 18.

Mr. Heisler said that the old system makes the condenser man responsible for the whole outfit, over most of which he had no control. A little defect in a piston-rod packing will admit sufficient air to make a serious dispute, if not to cause a rejection. On an otherwise tight air chamber, it needs only the equivalent of an orifice one-sixteenth of an inch in diameter to reduce a 28.9-inch vacuum by half an inch, and one-eighth-inch diameter to reduce it seven-eighths of an inch, the vacuum being produced by a dry-vacuum pump having a piston 20 inches in diameter, 12 inches stroke, running 120 strokes per minute, and holding the vacuum within 0.3 of the barometer previous to admitting air.

The Gas Power Section of the A. S. M. E.

The Detroit meeting of the American Society of Mechanical Engineers was marked by the first simultaneous meeting of its first special division, that devoted to gas power. Dr. Charles E. Lucke, of Columbia University, president of the section, was in the chair.

The committee on standardization, the appointment of which was authorized at the February meeting, presented a progress report which took the form of individual communications.

J. R. Bibbins suggested that for small high-speed gas engines, brake horse-power should be used in rating. Although large, slowly moving engines may be indicated, it is difficult to draw the line where the use of the indicator should cease and power measurement in brake horse-power begin. In all tests of large engines, both indicator and electrical readings should be taken. Capacity, he thought, should be expressed on the basis of continuous

operation for full-load rating and for a definite number of hours at maximum overload.

Overload Capacity—Conservative builders have consistently held down their overload rating to provide for operative contingencies, for example, weak gas. The range of fluctuation, or at least the lower limit in heat value, should be definitely stated, also the composition of the gas.

Altitude—Engines rated at sea level will have an appreciable advantage over those rating at an altitude. In specifications it would generally suffice to state the altitude of the works and the committee might insert a table or curve showing the theoretical decrease in engine capacity with increase of altitude. In case of very high altitudes, as Mexico and the far West, ratings would naturally be based on the altitude of the proposed installation.

Speed—Normal rated speed should be identified as that to be attained at full load; intermediate ratings implying, of course, slightly higher speed.

Gas Supply—The general character of the gas and its fuel source should be noted, its effective heat value under standard conditions (62 degrees Fahrenheit, 30 inches of mercury, dry) and the amount of foreign ingredients present in grains per cubic foot, percentage of free hydrogen in the mixture, temperature of delivery to the engine, and the permissible range in pressure or suction, also the permissible range in heat value or the minimum heat value.

Speed Regulation—A definite speed variation should be stated in terms of drop from no load to full load, likewise momentary variation for a definite range of load, in terms of normal average speed.

Engine Efficiency—Should be expressed in terms of effective heat value until a combined gas-vapor cycle comes into use. For the present, let us not confound a definite engine efficiency by introducing the indefinite factor of latent heat of water vapor. Engine efficiencies should be given for full to half load at least.

Producer Capacity—The producer should be rated upon its ability to gasify coal. It would be more accurate to rate on B.t.u. output of standard gas, but this is impracticable. Should the builder desire to rate on a special coal, he might insert a clause limiting some of the constituents. In specifying sizes, a maximum as well as a minimum screen should be mentioned. A mixture of many sizes packs the producer as badly as a very small fuel. As a usual thing the flexibility of the producer will more than meet the overload possibilities of the engine.

Producer Efficiency—Can only be specified in terms of B.t.u. output, involving volumetric measurement, which it is usually impossible to determine except by calibration of the engine. As we are dependent upon the engine as a gas meter, we must be consistent and determine the efficiency of the producer in like terms, that is, the ratio between heat output in standard gas, and heat input in fuel for the fire.

Producer Regulation—An important point is the property of the producer as regards the regulation of heat value of the gas and its pressure as delivered to the engine. Quality regulation is covered by the engine-capacity clause "with gas of not less than so many B.t.u. heat value per cubic foot."

Hydrogen Content—This may be expressed as a percentage by volume of the gas, a percentage by volume of combustible in the gas, a percentage of the heat value of the gas per mixture, or a percentage by volume of the mixture. The last appears to be the most explanatory. The first conveys no impression of the commercial value of the gas. The second is better in this respect. The third presents widely varying values.

Properties of Gases—Mr. Bibbins suggested a comparison of authorities and the compilation of a table covering calorific values of different combustible constituents at 30 inches of mercury, 32 degrees and 60 Fahrenheit; air and oxygen required for combustion; specific heat and weight; this table to cover the ordinary constituents of gases, as well as a number of the paraffin and olefine series, both saturated and unsaturated.

Standard Gas—In general practice the volumetric correction for water vapor has been ignored, whereas the correction therefor is appreciable. On the basis of 32 degrees Fahrenheit water vapor is entirely excluded by deducting from the total pressure of the gas the vapor tension of the entrained vapor at the proper temperature, which values may be obtained from a hygrometric table.

Auxiliaries—A definite statement of the gas, power, or coal consumption should be included in the specification.

Thermal Standard—The term "efficiency ratio," made use of by the code and defined as

$$\frac{2545}{B.t.u.\ per\ h.p.\text{-}hr.}$$

is not the efficiency ratio in the generally accepted sense; it is the absolute or kinetic efficiency. The British code contains the same term as thermal efficiency, but elaborates with the term "efficiency ratio," which it defines as the percentage of heat available in the Rankine-Clausius cycle, which the engine turns into useful work. This term applied to the above fraction appears to be a misnomer. It might be better to refer to the term "absolute" for the fraction above noted, adhering to the term "efficiency ratio" when referring actual consumption to the ideal Rankine cycle. The right start has been made in adopting the air cycle. The Rankine cycle assumes that the heat rejected is returned to the boiler at the same temperature as the exhaust steam. Have we a direct analogy in the case of the air cycle, or must we consider the rejected heat as lost?

Gas Measurement—Assuming the holder as the only practical means of quantitative measurement, pressure and temperature readings must be taken close to the holder outlet.

Assuming that a standard will be adopted for the hygrometric condition of the gas, either dry or saturated, at 62 degrees, it will be necessary to take hygrometric readings of both gas and air entering the engine, in order to determine the humidity of the mixture before combustion.

Jacket Water—Volumetric measurement should be made at the inlet to cover the loss by vaporization in running the jacket water hot. The thermometer should be far enough removed from the engine to insure a good mixture of the water from the different circuits and yet not so far as to make the radiation loss important.

Indicators—Would it not be well to recommend, or perhaps specify, that indicators of the outside-spring type be employed? The steam code does not absolutely disbar the taking of successive cards from one indicator after another, and it tolerates the use of three-way piping. In gas-engine work it is seldom that two consecutive diagrams are exactly the same and duplicate and simultaneous diagrams are more desirable.

With respect to the contention between Professors Schroeter, Schoerttler, Stodola and Herren and Diesel, Mr. Bibbins believed that the only way out of the muddle is to adopt a definite phraseology, and that the present practice of deducting all negative areas should be adhered to, but the net area resulting should not be labeled by the general term "indicated horse-power," but by some such term as "net" or "effective horse-power." The difference between the total and effective diagrams in the case of the two-stroke-cycle and Diesel engines is too great to be ignored.

Speed—The present code declares "that there is no recognized standard for fluctuating speed," which I presume covers both cyclical variation in reciprocating prime movers, and momentary variations due to sudden changes in load. Is there any reason why this ambiguity should not be cleared up?

Stopping and Starting—The problem is simple with a small suction producer holding but a small quantity of fuel, but with a 200- or 300-horse-power producer the method prescribed by the present code is impracticable. The only alternative is the flying start and stop. Some methods covering these points in producer testing should be outlined.

PRODUCER PERFORMANCE

H. F. Smith, another member of the committee, and general manager of the Smith Gas Power Company, paid particu-

lar attention to the question of producer performance. He felt that while producer regulation might not be of such vital importance as engine regulation, it is, nevertheless, sufficiently important to warrant discussion. It is possible to use, as a basis for producer capacity: (a) The horsepower that can be developed from a gas engine supplied with gas from the producer, (b) the volume of gas generated in unit time, (c) the weight of coal gasified in unit time, and (d) the thermal energy delivered in gas in unit time.

The first of these (a) is really only applicable to a complete power installation; (b) is incomplete, and meaningless unless qualified by a specification as to the quality of each unit volume of gas, in which case it is simply a form of (d); (c) is also incomplete unless modified. A boiler furnace will convert into gaseous form large amounts of coal, but cannot be said to have any capacity as a gas generator. The method of rating indicated as (d) has already been adopted as standard for many forms of apparatus, and it would seem to the writer that an expression indicating the thermal energy delivered in gas in a unit of time could be used as a measure of the capacity of any producer used for any purpose.

Two considerations come at once to prominent notice as exerting a marked influence on plant capacity, first the net available area for the passage of gas through the apparatus; second, the rate at which the chemical reactions involved can be brought to completion. The first is influenced greatly by the size of the fuel, the worst possible case being found in a fuel consisting of a mixture of sizes. The second depends upon the superficial area of fuel exposed to the action of the blast, the time of contact between fuel and blast, and the temperature of fuel and blast at the time of contact.

It would appear that for the protection of the purchaser, the output of the producer in available thermal energy should be distinctly specified, while for the protection of the manufacturer, the limiting conditions of performance, such as the size of the fuel, the fusibility of the ash, the quantity of ash per unit of thermal energy in the fuel, and the quantity of volatile matter, should be specified.

J. B. Klumpp, a member of the Gas Engine Committee of the National Electric Light Association, said that the so-called "net" or "available" or "effective" heating values, as used in writing contracts or guarantees, are misnomers, and economizing appliances could be attached to some apparatus to produce results of over 100 per cent., if these terms were considered. The latent heat in the products of combustion is not lost until the gas and air necessary for combustion are raised at least to 212 degrees, when the sensible heat amounts to a considerable proportion of the total heat lost. It might be well to express the "effective power value" as being the true heating value less the latent heat contained in the water vapors in the products of combustion.

THE BY-PRODUCT COKE OVEN

This paper, by William Hutton Blauvent, was the first paper presented. It dealt with the construction of the coke oven rather than with its availability as a producer, but brought out some interesting remarks by Mr. Bibbins regarding the coke ovens at Lebanon, which will supply gas for the public-service companies. The percentage of hydrogen is stipulated to be not over 50, and it has been found that it can be kept down to that figure without difficulty. The sulphur is removed by oxide purifiers, and the gas can be rendered comparatively free from sulphur by renewing the oxide weekly. At the end of a week's run the reduction is about 75 per cent. The amount of sulphur in the gas produces no deleterious effect upon the engine so long as the piston-rods are protected by forced lubrication. At the cost at which it is possible to supply this gas, it would be entirely out of the question to operate a steam plant. The critical feature of the situation is that the coke company will not guarantee a supply of gas, but simply sells it as it is produced, and the user has to take it as it comes.

C. P. Atwater suggested that corrosion from sulphur could be avoided by running the cylinder hot enough to eliminate all moisture in the exhaust gases, so that the sulphur could not be taken up by the water and attack the rods. In reply to his inquiry, Mr. Bibbins told him that there were 3 grains per cubic foot of gas. The rods had been calipered after having been in service for a year, and there was very little variation in diameter.

Professor Fernald said that in the Government testing station at St. Louis they had tested bituminous coal, lignites and peat; the highest percentage of sulphur was 8.2 in the California lignites. The gas from these coals was used without any remarkable effects in their engines without any attempt to remove the sulphur. When the plant was carried to Norfolk, they left the purifier in St. Louis. The engine has shown no pitting, even when examined with a magnifying glass.

Mr. Rathbun said that in a case where difficulty had been encountered in lubricating the piston-rod of a gas engine, he had suggested that hot, rather than cold, water be circulated through this member, the adoption of which suggestion obviated the difficulty.

POWER PLANT OPERATION ON PRODUCER GAS

In a paper having the above title, Godfrey M. S. Tait described a series of experiments which led to the design of his gas producer for power producers, and also described his producer system. The peculiarity of the system lies in the method of keeping down the temperature of the fire to avoid clinkering; this consists of delivering to the producer fire a mixture of air and engine-exhaust gas, instead of air and steam. The result eliminates hydrogen from the fuel gas delivered by the producer to the engine, and also avoids fluctuations in the quality of the gas and permits the engine to work with higher compression than would otherwise be practical.

In the ensuing discussion, Mr. Smith said he thought that Mr. Tait had put his finger on the weak point of producer practice—the variation in the percentage of hydrogen. His company had applied a different solution, that of maintaining a constant percentage of hydrogen. He thought that the use of the exhaust gases containing a large amount of inert nitrogen might be prejudicial to efficiency, as had been pointed out by Mr. Loomis.

Mr. Stillman said that at the time of the meeting in New York he was just starting to build a producer of a most peculiar type. This had turned out not to be a success, because it was not possible to clean it out properly. When they broke through the clinker, they burned a hole through the 12 inches of the concrete bed.

H. W. Jones said that he was indirectly in charge of 700 gas engines, and he had yet to see the first engine that had failed to operate successfully or a case where the owner had complained of his gas bill or of the reliability of the engine. He had visited a plant where Mr. Tait's producer was at work and the engineer absolutely did not have to get out of his chair.

Mr. Tait, in closing the discussion, said that while the thermal efficiency of his producer might not be quite as high as that of others, the combined efficiency of the whole plant would be as high, or higher, on account of the improved efficiency of the engine.

Other Papers

Other papers read before the Gas-power Section were: "The Horse-power, Friction Losses and Efficiencies of Gas and Oil Engines," by Lionel S. Marks, and "A Simple Method of Cleaning Gas Conduits," by W. D. Mount. These cannot be abstracted briefly, but will be given space in another issue.

Other Features of A. S. M. E. Meeting at Detroit

During the evening of Wednesday, June 24, the society listened to a lecture by Dr. John A. Brashear on "The Contributions of Photography to our Knowledge of Stellar Evolution." The attendance was large, and to those who were not acquainted with the revelations of the photographic telescope, the lantern slides were themselves revelations.

Thursday morning there was an excursion to the Great Lakes Engineering Works, at Ecorse, to witness the side

launching of a 10,500-ton lake steamship. The trip was by water.

The professional sessions were resumed Thursday afternoon by the reading of a paper on "The Surge Tank in Water Power Plants," by R. D. Johnson. The paper describes a device intended to aid in the speed regulation and pressure relief of water powers with long pressure pipes and high velocities. The device is simple enough mechanically, but the determination of its proportions is a matter of some difficulty and the paper is consequently quite mathematical, as was the discussion.

The second paper was entitled: "Some Pitot Tube Studies." It was submitted by Profs. W. B. Gregory and E. W. Schoder. The paper describes some experiments undertaken to determine the effect of curves in pipes as regards the distortion of the distribution of velocities, together with the distribution of velocities in the curve. The paper contains both diagrams and tables, summarizing the results of the experiments.

The third paper was: "A Comparison of Screw Thread Standards," by Amasa Trowbridge. The paper gives curves comparing the Pratt & Whitney standard thread for machine screws, the United States standard bolt thread, the standard of the Association of Licensed Automobile Manufacturers, and the machine-screw standard of the society. The paper was read by Mr. Burlingame, who also discussed it. He stated that for many purposes the Brown & Sharpe Manufacturing Company had long used a finer thread than that of the United States standard, and he offered a formula of his own devising for a standard to meet conditions for which that standard is unduly coarse. This formula, while different from that on which the society's machine-screw standard is based, gives nevertheless the same results for all screws included within the range of that standard, while, extended beyond that range to larger sizes, it falls in essentially with the Brown & Sharpe practice.

It was pointed out in the discussion that there is a real need and demand for many purposes for finer threads than those given by the United States standard, and that under these circumstances miscellaneous shop standards are springing up. It was urged that under these conditions the time is ripe for the society to provide a standard to prevent the further growth of this diversity and a resolution was passed calling upon the council to appoint a committee for this purpose.

The concluding paper of the session was entitled: "The Identification of Power House Piping by Colors," by W. H. Bryan. The paper pointed out that the number, extent and variety of pipe lines in modern power plants has become so great as to result in confusion, uncertainty, delay and even accident, a condition which in many plants has led to the painting of different lines with distinctive colors. The author believes that a standard scheme of colors would be extremely advantageous and that the formulation of such a standard is an appropriate subject for the society to take up.

The discussion was entirely favorable to the idea and it resulted in a resolution referring the matter to the council with power to appoint a committee to undertake the formulation of such a scheme.

Defects in an Indicator Reducing Motion

By Walter H. Adams

A short time ago the writer designed a reducing motion for a gas engine, which did not prove satisfactory as originally designed, and was corrected as outlined in the following: The motion was designed rather hastily, and no method of checking was applied to see if a proper reproduction of the piston motion was procured.

Tests on the engine showed uniformly an efficiency of over 100 per cent. on all loads except the lightest. This, of course, showed a defect somewhere, and careful checking of all the factors that entered into the efficiency brought the error to the reducing motion. The indicator was tested, revolution and working-stroke counters were examined and the friction brake was carefully inspected during the test to make sure that it registered the proper load on the engine. The effect of a bad reducing motion had never been brought to the writer's attention in such an emphatic manner, and so it was the last factor that was examined to find the trouble.

The engine was a 7-horse-power, four-stroke-cycle, stationary, horizontal machine of Foos make with a hit-or-miss governor, and had a speed of 325 revolutions per minute during the tests. The gas-supply pipe was not large enough, which caused a throttling of the mixture and reduced the maximum pressure in the engine cylinder at explosion.

Anyone familiar with gas-engine testing knows that it is difficult to secure a satisfactory reducing motion owing to the lack of a suitable point for its attachment. The most simple reducing motion that was considered usable was the form of four-bar linkage known as the crank and rocker. It is shown in Fig. 1. The crank A rotates with the shaft of the engine, and this rotary motion is transferred to the rocker B through connecting-rod C. Arm B rocks between the limits B and B_2. The fourth link is stationary and is formed by the frame of the engine. It is shown dotted at D. Shaft F carries a circular sector E such as is used on many reducing motions. This sector rocks with B and forms an attachment for the cord to the indicator.

This reducing motion cannot give an exact reproduction of the piston motion under any conditions, as the angle α_1 cannot equal α_2. The angles can be made nearly equal, and in this case this was done.

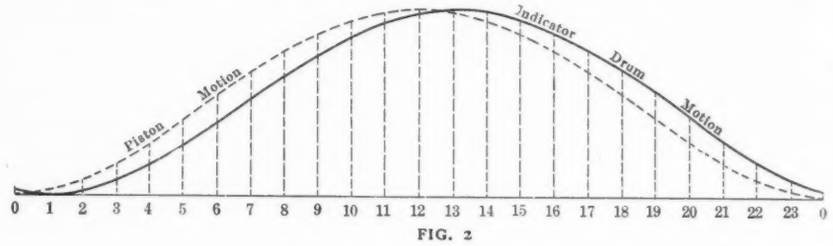


FIG. 2

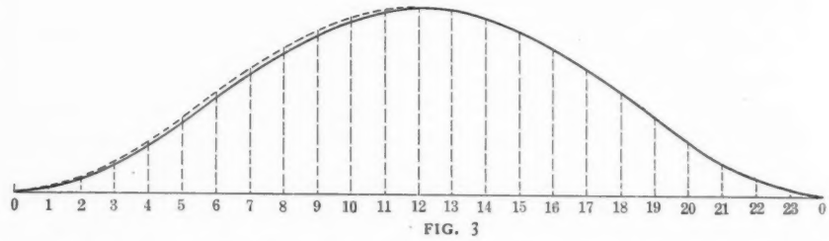


FIG. 3

As originally laid out crank A coincided in position with the crank of the engine, as shown in Fig. 1. Using this linkage the full curve of Fig. 2 was drawn, the abscissas representing crank angles measured from the zero position and the ordinates representing the unwinding of the indicator cord from the circular sector E or the motion of the indicator drum. In this curve it will be noticed that the zero position of the crank does not give the zero position of the drum. On this same diagram was plotted the piston displacements from the dead-center marked zero. These are plotted to the same scale as the indicator-drum motion, the ratio of the crank to the connecting-rod being one to six.

These two curves show the relation between the piston displacement from the dead-center and the drum displacement from its dead-center for any position of the crank. For example, at point 6 the piston is displaced 1½ inches while the

drum is displaced 1 1/16 inches. A study of the curves shows that the displacement of the drum from its dead-center does not coincide with the displacement of the piston from its dead-center for the same crank position. The full curve was sketched on tracing cloth and then moved over the dotted curve until the two zero positions coincided. The two curves then had the form shown in Fig. 3. This diagram is secured by setting the crank *A* 15 degrees ahead of the engine crank. The full curve lags behind the dotted curve by the distance *L* to *M*, Fig. 1, or 15 degrees. In other words, when the piston is on dead-center, the indicator drum has a small distance to move before it will reach one extreme of its motion.

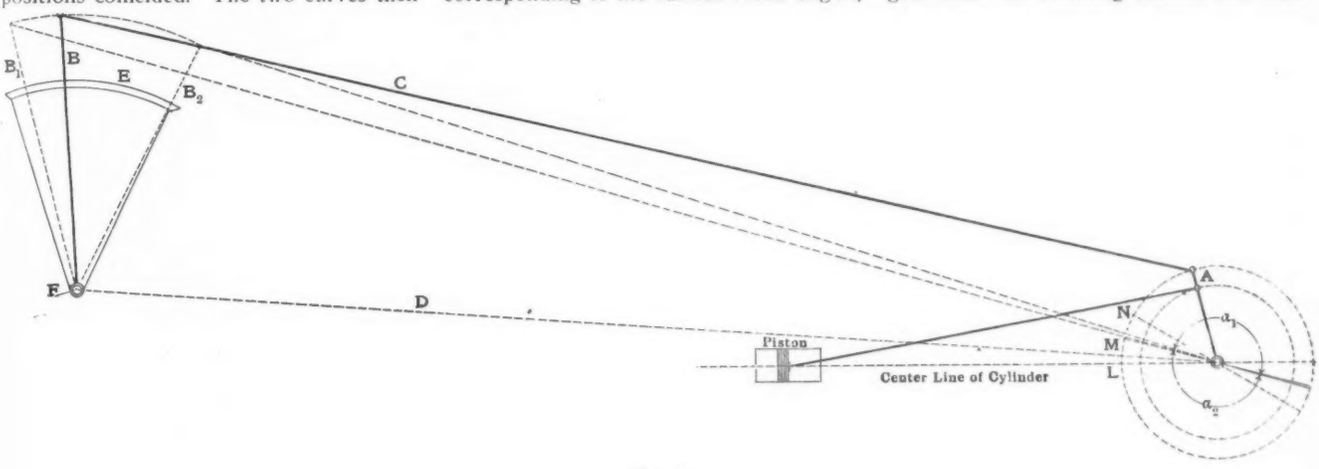


FIG. 1

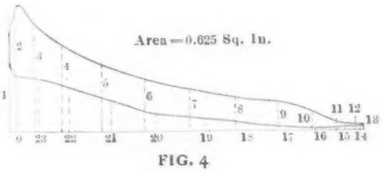


FIG. 4

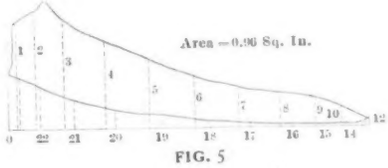


FIG. 5

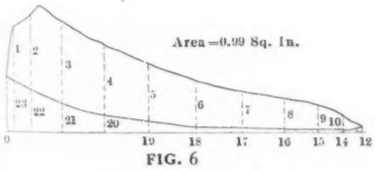


FIG. 6

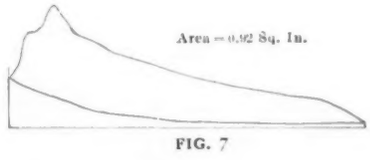


FIG. 7

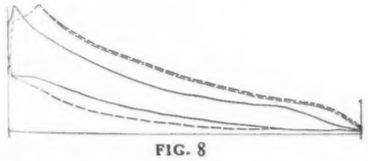


FIG. 8

This is not desirable in any reducing motion. In Fig. 3 the diagram shows a close agreement between the two curves and is considered sufficiently accurate.

Indicator Cards as a Check

A 160-pound spring was used throughout the series. Fig. 4 shows a card taken with the original reducing motion. It is rather thin, and the pressure is not as high as it ought to be. This was attributed to the fact that the gas supply was inadequate under the present arrangement of piping. A comparison of brake horse-power and indicated horse-power showed an efficiency of about 103 per cent.

This card was fastened to the drawing board and ordinates drawn at the points corresponding to the various crank angles, as shown. Two new cards were then constructed to make the old card fit the curves in Fig. 3. These cards are shown in Fig. 5 and 6, Fig. 5 being for the full curve and Fig. 6 for the dotted curve. The method of procedure was to scale the pressure at the point 0 in Fig. 4 and lay off the measurement as an ordinate at point 0 in Fig. 5. In the same way the other points were determined, and this was repeated for Fig. 6.

In Fig. 8 the cards of Figs. 4, 5 and 6 are shown superimposed, and show at a glance the effect of the bad reducing motion and in addition the variation between the motion as it is now in use and what it should be if it were absolutely correct. The cards were then measured with a planimeter, and the areas obtained are given on the figures.

Fig. 6 shows the card that would be secured if the reducing motion gave an exact reproduction of the piston motion. The difference in area of Figs. 5 and 6 is about 3 per cent. The mean effective pressure will vary by the same per cent., but this is considered sufficiently accurate. If greater accuracy is desired, any card may be reduced to that of Fig. 6 by the same method. The effect of changing the reducing motion was to increase the area of the card from 0.625 square inch to 0.96 square inch, or 54 per cent.

Fig. 7 shows a card taken from the engine after the reducing motion had been adjusted as previously explained. The condition of loading and speed were as nearly identical with those when Fig. 4 was taken as was possible. A comparison of Figs. 4, 5 and 7 show that the original trouble has been corrected, as the area and the shape of the card show a fair agreement with Fig. 5. It is almost needless to say that the efficiency is now a reasonable value for that type of engine.

A study of the present case has impressed very forcibly upon the writer the necessity of being sure that the reducing motion gives a correct reproduction of the piston motion. Many of the reducing motions in use at the present time do not give a correct reproduction of the crosshead or piston motion, but it is taken for granted that they give a close enough approximation. By using the method outlined any reducing motion can be checked and its accuracy determined.

No general rule for the allowable error can be given. It cannot be said offhand that this reducing motion is good enough or that one should be thrown away. The pantagraph and most of the reducing wheels made by indicator manufacturers give motions theoretically correct, but the stretch of the cord and the inertia of the drum and moving parts introduce defects of greater or less magnitude. Every user of an indicator should test it, and then decide if it is accurate enough for his purpose. For testing small engines and valve setting, a high degree of accuracy is not required. If a test is to be made on an engine to determine whether or not it fulfils certain conditions specified in the contract, then the indicator and reducing motion should be tested thoroughly, as the acceptance or rejection of the engine may depend upon them.

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Receiver Pressure and Distribution of Load

The question of receiver pressure and proper distribution of load between the cylinders of compound engines is of practical interest to most engineers. It is assumed by some that in all cases an equal amount of work should be done in each cylinder; that the receiver pressure should not be lower than the release pressure of the high-pressure cylinder, and that if there is to be any difference in the amount of work done in the cylinders, the low-pressure cylinder is the one in which the extra work should be performed.

There are several reasons for the installation of compound engines in power plants, the chief of which is the economy of its operation as compared with the operation of a simple engine. This reason is sufficiently good to make the statement of any other reasons unnecessary. As the engine is installed primarily for economical reasons, it would seem that the economy of its operation should be of prime importance—a matter to be absolutely assured. Theorizing and guesswork will not yield data from which reliable conclusions can be drawn. Only intelligent tests, combined with logical analyses of the results, will determine the best course to be pursued under each set of conditions.

It may be taken for granted that the hight at which the governor revolves when the engine is carrying a given load determines the length of cut-off and is undoubtedly a measure of the quantity of steam used. The higher the governor the shorter the cut-off. If with the governor revolving at a certain hight a change is made in the receiver pressure, by altering the point of cut-off in the low-pressure cylinder, the governor will at once take a different position, either higher or lower than before. With the governor revolving in the highest possible position with a given load on the engine, it is evident that the engine is using the least possible quantity of steam for the work being done. This being true, it follows that in seeking for the highest degree of economy in the operation of compound engines no attention will be paid to the distribution of load between the cylinders, or to the receiver pressures as such, except as factors in the problem of finding the highest possible plane in which the governor can be made to revolve with a given load on the engine. Possibly with some loads, some cylinder ratios and some steam pressures this plane may be found when the steam in the high-pressure cylinder is expanded to receiver pressure and an equal amount of work is being done in each cylinder; but much oftener it will be found when there is a drop of from five to fifteen pounds between the high-pressure exhaust opening and the receiver, and a difference in the amount of work done in the cylinder of from 5 to 20 per cent. of the total work of the engine, the larger amount being done in the high-pressure cylinder.

The Saving of Oil

Within the last ten years the railroads of the United States saved one million dollars in the cost of oil used by them, as shown by the statistics brought out in the hearings of the Government suit against the Standard Oil Company. Although this total covers the savings of seventy or more railroad companies, its significance is greater when it is considered that railroad rolling stock and equipment are much heavier than ever before. Locomotives are a third larger and heavier, an increase has been made in the weight of freight and passenger cars, and, to correspond, the total bearing surface is much greater than it was ten years ago. Some of the roads show an annual decrease in the cost of lubrication of from seventy-five to eighty per cent. over similar data recorded a decade before; others a decrease of sixty, fifty and forty per cent. Of the entire seventy systems, only five show an increase, and this, according to expert opinion, was due to the non-adoption of modern methods.

It is the consensus of railroad opinion that the saving was effected by the coöperation of the various companies with expert educators employed by the Galena Signal Oil Company, which supplies oil to ninety-seven per cent. of the railways in this country. These educators are constantly at work instructing the engineers and oilers as to the most economic use of oils, and are always ready to consider any improvement in constructional detail tending toward economy. This, of course, is but natural when considered from the standpoint of the Galena company, which agrees to lubricate a railroad for ninety per cent. of the cost for the same service prior to the first contract. If the railroad uses more oil than the contract calls for, the oil company is the loser, so that it is to its interest to effect as great a saving as possible.

If under adverse conditions a saving of the amount stated can be effected by the railways, is it not possible to produce as great, or, perhaps, a far greater saving in the power plant? Are the average stationary engineer and oiler men of greater intelligence or more proficient in their professions than the locomotive engineer, or are the conditions so widely different that a comparison is impossible? Is the stationary engineer better acquainted with the lubricating qualities and the selling price of oil than the man at the locomotive throttle, or can he conduct a test to better advantage in determining the constituents of the oil? After a fair consideration, the answer in all probability will be negative, and it will be agreed that the average sta-

tionary engineer is not above a little expert instruction in lubrication matters. With this point in mind, it is needless to say that an arrangement similar to that enjoyed by the railways of the country would be of great value in the power-plant field, and, besides offering a course of instruction to engineers in general, would mean a considerable saving to plant owners.

The Operating Steam Engineer

There were things said of him at the recent meeting of the American Society of Mechanical Engineers which will not add to the self-esteem of the operating steam engineer. One of the papers presented dealt with some tests of small high-speed engines, made after they had been running for some time, and without any attempt to put them into test condition. They showed that the engines were using two or three times as much steam as such engines are commonly supposed to require. Most of the engines had balanced valves with adjustable cover plates, and in the discussion of the paper it was very seriously questioned whether it paid to expend so much brainwork upon the design and so much money upon the construction of refinements which depended for their successful operation upon a set of men who did not understand and could not appreciate them.

To the onlooker the discussion would have appeared to have been anything but complimentary to the operating engineer. As a matter of fact the operating engineer was not involved. The adjustment and the keeping up to its work of a balance plate is one of the simpler details of an engineer's job. A man who could not only not adjust such a plate, but tell when it needed adjustment and keep the engine up to its initial efficiency, has no claim to be called an engineer. The trouble is that the purchasers of such engines do not put them in charge of engineers, but of laborers. We do not know where the tests in question were made, but we venture to say without fear of successful contradiction that the men in responsible charge of these engines were considered as laborers, not as responsible heads of departments; that they had discharged all the duty that was expected of them when they kept the engine turning over the requisite number of hours per day; that they were held in no way responsible for the steam consumed, and would get no credit if they saved a half of it; that instead of being expected to keep the engine up to the mark, they would, in most instances, be reprimanded for taking it apart; that instead of being paid for the overtime necessary for such inspection and adjustment while the engine is out of service, or, better, a salary which would encourage such out-of-hours service, the men are paid less than their fellow laborers receive for laying bricks in a row and pasting them together with mortar.

There are plenty of good steam engineers to be had. We will supply Mr. Engine Builder or Mr. Engine Buyer with men who will keep their machines up to the best efficiency, and at the same time will get the best out of the boiler pumps and entire system, but not for two dollars a day.

It is not fair that the craftsmanship of the steam engineer should be thrown into disrepute because men employ laborers and dub them "engineers."

Another left-handed compliment to the steam-engine runner was handed out in the session of the Gas Power Section when one of the participants delivered himself of the dictum that "If you want a man to take care of a gas engine, don't take a steam engineer. He has too much to unlearn. Take a good machinist, show him the few simple things that are necessary for him to do and charge him to leave the engine alone otherwise. You can make a better attendant in two weeks out of a machinist who has never seen an engine before than out of a man who has run a steam engine all his life."

Another case of laborer, and a bad one. The gas engine is on trial for its life. It has demonstrated its superior efficiency from the fuel point of view, and the costly period of experimentation is drawing toward that of standardization and lower first cost; but the buying public needs assurance of its dependability. An interrupted service may easily offset a fifty per cent. saving in the coal bill. The demand is for men who know as much about the processes involved in the gas producer as a first-class steam engineer knows about boiler practice, for men who can select a plant adapted to the work that it is to perform and make it do that work dependably and continuously as well as economically. There are such men, men who have studied the gas engine from the operative point of view, who have studied the principles involved, have learned the essentials of effective operation, who understand the requirements and limitations of the producer and the mechanism of the engine, who are acquainted with the crotchets of the outfit, capable of quickly diagnosing trouble and applying the proper remedy, wise in the ways of the apparatus and competent to foresee and head off difficulty. Such men would have turned many of the failures which stand charged to the record of the gas engine into abundant and assuring successes. It is the cheapest kind of short-sighted policy to discourage the development of men like these by putting expensive installations of gas-power producing apparatus into the charge of men whose only qualifications for the job are the ability to handle tools, for which they will have no use, and a two-weeks' instruction course under an erecting man.

Lead and Compression

In discussing a question of lead and compression the engineer is more naturally inclined to twist his logic to fit his preconceived idea than to take each element in the case and analyze it. The engineer who wishes to see what he considers a handsome indicator diagram, with perpendicular induction lines showing ample lead of steam valves and a compression curve rising to about two-thirds of the hight of the diagram, gives warm welcome to the statement that compression does not cost anything because the compressed steam, in expanding, gives back to the fly-wheel all of the energy absorbed in the compression and fills the clearance space with steam without cost of coal or energy. He assumes that this is true and bases his argument upon it without analysis and his conclusions will be right or wrong (however logical they may be), as the premises assumed are right or wrong. There is the other engineer, however, who is also particular about the appearance of the indicator diagram and who maintains that a correct analysis of the statement that compressed steam in expanding will give out as much energy as it absorbed in the process of compression will show that the statement is untrue; the expanding steam cannot give back all of the energy it has absorbed. This being true, compression instead of being had for nothing will cost something. This class of engineer argues that any machine should be allowed to perform its work as little hampered by internal friction as possible, if the operator desires to get the greatest output with the smallest possible expenditure of energy. Lead and compression introduce pressure in the cylinder at a time when pressure cannot possibly have a forward rotating effect upon the crank-shaft, and as steam is used in the engine for the sole purpose of turning the shaft, all steam and energy that do not tend to this end are wasted. He claims also that lead and compression create friction on all bearings and tend to retard the rotation of the shaft.

It lies within the power of many engineers to test the correctness of these two opposite views. Take an engine which has a constant load. Take indicator diagrams with the valves set in the conventional manner, giving both lead and compression. Then change the valve setting so that there shall be an absence of lead and compression. Let the admission line lean inward slightly and the compression line be hardly noticeable and again indicate the engine. As the effective work of the engine is the same in both cases, if there is any difference in the indicated horse-power this difference will show whether there is any basis for the claim that compression nullifies the effect of clearance and does not cost anything.

Cooling Condensing Water by Means of Spray Nozzles

Cooling condensing water by means of a spray system provides a water supply independent of any outside source, other than that sufficient to supply the small amount of water lost by vaporization, for which purpose a dug well usually will furnish all that is needed. At the plant of the Delta Spinning Company, Frankford, Philadelphia, Penn., a spray-cooling system has been in operation a little more than one year. The steam plant consists of five 150-horse-power return-tubular boilers and one 800-horse-power Corliss engine operating with an average load of 650 horse-power. The engine is operated condensing, a jet condenser being located in the basement. The boiler feed-water passes through a heater placed between the engine and the condenser.

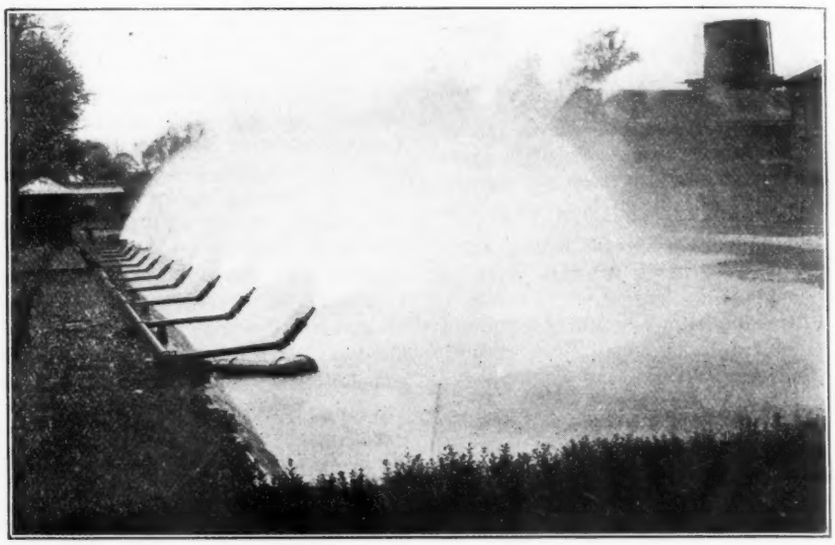


FIG. 1. PART OF THE SPRAY SYSTEM AND ONE OF THE PONDS

When the condensing system was first installed, two cement-lined ponds were constructed, each 50x150 feet and 7 feet deep. It was thought that the amount of water in these ponds (94,000 gallons) would permit of its being used over and over again for condensing purposes, but the temperature of the water remained altogether too high for efficient service. J. M. Foreman, of Schutte & Koerting Company, Philadelphia, was consulted, with the result that the spray system illustrated in Figs. 1, 2 and 3 was installed. Figs. 1 and 2 are reproduced from photographs of the ponds, and Fig. 3 is a plan view of the ponds and spray-system lay-out.

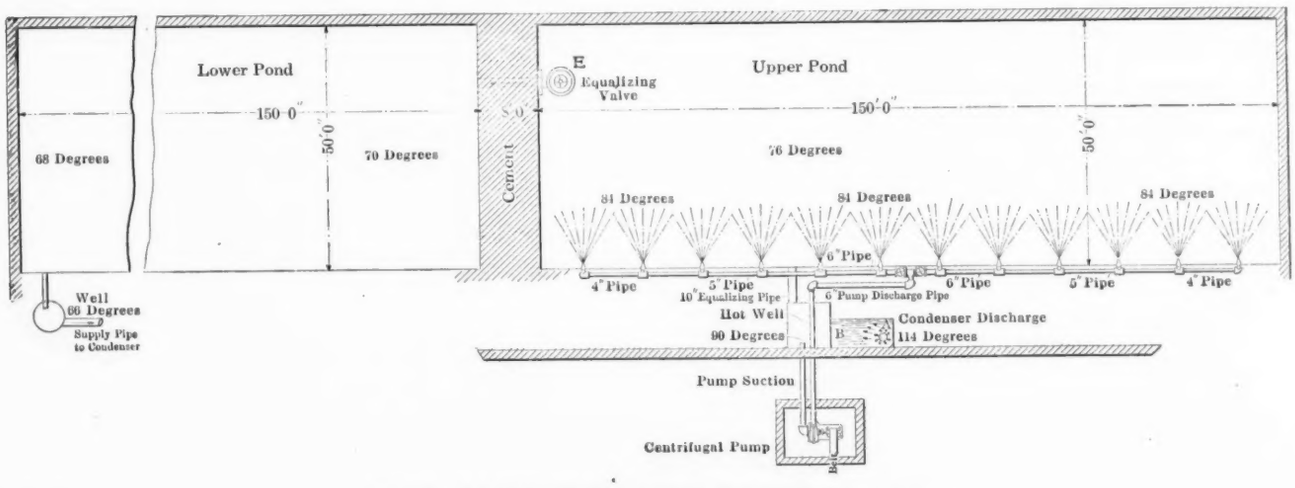


FIG. 3. PLAN VIEW OF PONDS AND SPRAY-SYSTEM LAY-OUT

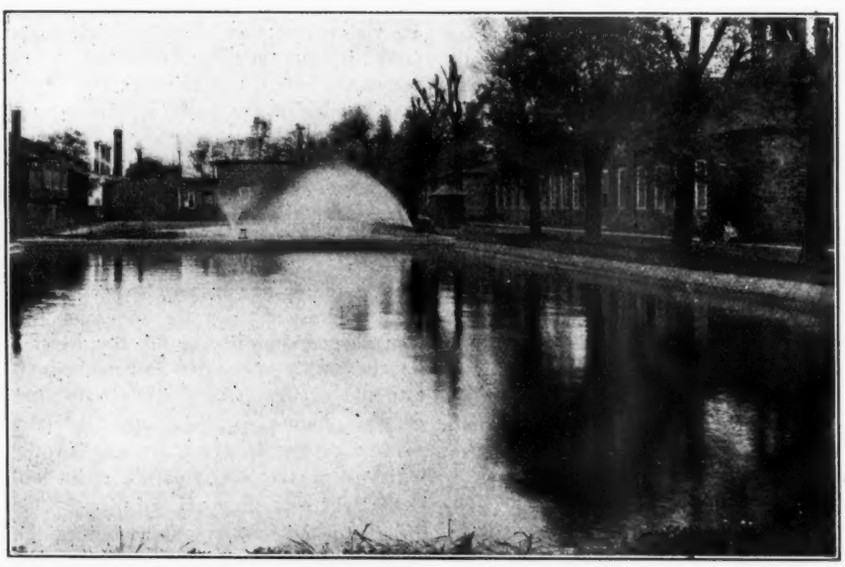


FIG. 2. ANOTHER VIEW OF THE SPRAY SYSTEM

Referring to Fig. 3, the condensing water is discharged through an 8-inch pipe at *A*, and, running through the sluiceway *B*, falls 2 feet into the hot-well, where the temperature of the water is lowered, due to a small amount of water which is permitted to enter the hot-well from the upper pond through a 10-inch equalizing pipe. The water is taken from the hot-well through the pump suction of a 5-inch centrifugal pump and discharged through the twelve spray nozzles under a head of 14 pounds. The discharge pipe from the pump is 6 inches in diameter and discharges into the 6-inch spray header midway between the two ends. The spray header is reduced to 5-inch and 4-inch

TEMPERATURE OF UPPER AND LOWER PONDS, AIR AND WEATHER CONDITIONS.

	8 A.M.		5 P.M.		Temp Air.	Weather.
	Upper Pond.	Lower Pond.	Upper Pond.	Lower Pond.		
Sept. 3	78	76	86	79	74 82	Hazy. "
Sept. 4	85	80	90	84	74 82	Cloudy and damp. Rain.
Sept. 5	88	83	90	86	74 80	Hot and cloudy. Hazy.
Sept. 6	82	86	84	84	70 74	Cool and cloudy. Clear.
Sept. 7	80	80	..	..	68 75	" "
Sept. 9	78	77	84	79	69 72	Cloudy and damp. " " "
Sept. 10	82	78	84	79	70 73	" " " " " "
Sept. 11	83	79	86	81	74 67	" " " Rain.
Sept. 12	81	79	83	80	66 74	Clear and cool. " " "
Sept. 13	79	76	84	80	65 74	" " " " " "
Sept. 14	81	78	82	12 o'clock 80	65 78	" " " " " "
Sept. 16	80	75	84	79	68 79	Hazy. Clear and hot.
Sept. 17	82	78	87	82	73 78	Hazy.
Sept. 18	82	79	82	78	65 60	 Rain.
Sept. 19	79	75	80	75	56 60	Rain. "
Sept. 20	78	74	83	77	60 70	" Cloudy.
Sept. 21	82	76	..	..	70	Rain.
Sept. 23	78	73	81	75	60 66	Rain.
Sept. 24	81	75	84	78	70 75	Clear.
Sept. 25	79	75	79	77	60 60	Clear and cool. " " "
Sept. 26	74	71	76	72	50 58	" " " " " "
Sept. 27	73	69	78	72	51 62	 Cloudy.
Sept. 28	78	70	79	72	58 64	" Rain.
Sept. 30	72	68	77	70	57 62	Cloudy. Clear.
Oct. 1	72	67	74	70	50 59	" "
Oct. 2	68	64	74	68	49 58	" "
Oct. 3	72	64	78	69	56 70	" "
Oct. 4	75	68	78	72	64 70	Rain. Clear.
Oct. 5	76	68	74	12 o'clock 69	58 64	" "
Oct. 7	68	62	73	67	58 69	Clear. "
Oct. 8	72	66	72	68	71 55	Rain Clear
Oct. 9	67	64	71	66	45 50	" "
Oct. 10	67	63	73	66	47 58	" "
Oct. 11	71	64	76	69	52 62	
Oct. 12	70	64	70	68	47 55	
Oct. 14	62	57	64	58	44 53	Clear. "
Oct. 15	61	56	66	59	43 53	" "
Oct. 16	65	58	70	63	40 53	" "
Oct. 17	68	62	74	66	46 58	" "
Oct. 18	71	64	77	68	50 63	" "
Oct. 19	71	63	72	64	42 48	" "
Oct. 21	64	54	67	59	39 46	" "
Oct. 22	63	57	71	60	36 52	" "
Oct. 23	72	58	84	62	46 59	 "
Oct. 24	74	59	86	64	39 48	" "
Oct. 25	82	62	90	68	42 53	" "
Oct. 26	82	64	84	62	40 48	" "
Oct. 28	72	56	82	60	53 47	 "
Oct. 29	75	59	84	62	42 50	" "
Oct. 30	76	60	85	63	40 45	" "
Oct. 31	80	60	86	64	36 43	" "
Nov. 1	81	62	90	68	36 47	"
Nov. 2	84	63	84	64	46 56	Cloudy. Rain.
Nov. 3 (Sunday)						
Nov. 4	66	54	76	58	44 48	Clear. "
Nov. 5	76	56	84	63	40 52	" "

pipes on both sides, each size of header supplying two spray nozzles. Each set of six spray nozzles can be cut out of operation at will by means of the valves shown.

The spray nozzle shown in Fig. 4 is of the centrifugal type, in which the water is given a centrifugal motion and, upon coming in contact with the atmosphere, is divided into particles, or spray. In this form, as it is projected through the air, the water creates its own continuous current. The act of disintegrating the water carries with it a lowering of the temperature, which added to the effect of the air current reduces the water temperature to nearly that of the surrounding air, or a temperature sufficiently low for condensing purposes. The water passes from the upper to the lower pond through a 10-inch pipe which is fitted with an equalizing valve, the stem and hand-wheel of which extend above the water level of the pond, as shown at *E*, Fig. 3. From the lower

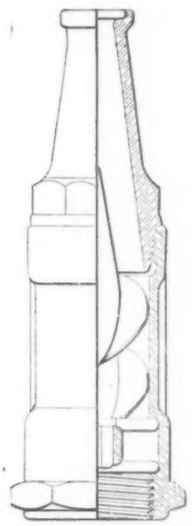


FIG. 4. A SPRAY NOZZLE

pond the water passes to a well, which was already dug, and from the well to the condenser.

On the day of the writer's visit to the plant the temperature of the water discharging from the condenser was 114 degrees. This high temperature was due to the condenser being a little too small for the amount of steam it is forced to handle. The temperature in the equalizing or hot-well was 90 degrees, and the water escaped to the air after passing through the nozzles at a temperature of 84 degrees. The temperature of the upper pond was 76 degrees, while that of the lower pond was 70 degrees at the upper end and 68 degrees at the lower end. The well temperature was 66 degrees. This made a drop in the temperature of the condensing water from the time it came from the condenser until it was used again, of 48 degrees.

The accompanying weather chart gives the results compiled by W. R. Garsed, general manager of the Delta Spinning Company, of observations during Sep-

tember and October and a portion of November of last year. The conditions found during September and October afford a fair conception of what may be obtained during the warmer months of any year. The log gives the temperature of the upper and lower ponds at 8 a.m. and 5 p.m., also the air temperature and weather conditions both morning and afternoon.

Before the spray system was installed the condenser received its water from a small creek, but owing to the large amount of refuse in the water a vacuum of only 22 inches could be obtained, on account of the valves becoming clogged with dirt and sediment. This necessitated operating the five boilers in the plant in order to carry the load. Since the spray nozzles have been installed four boilers carry the load and a vacuum of 26½ inches is maintained on the condenser.

The total cost of this system should not be used as a basis in estimating the cost of constructing a spray system of similar size, as the expense of making the ponds, which are not necessary, amounted in round numbers to $3000. The cost of the spray system was $900, which includes the centrifugal pump, spray nozzles, piping, etc. The cost of labor required for installing the system in this instance was practically nothing, the work being done by the engineering force at the works. The system is so simple that any engineer can easily construct it, the cost of the installation being confined to the cost of the pump, nozzles, piping and construction of the cooling area.

In many instances the cooling pond is as nature made it, all ready for use, as is the case of the Cleveland municipal electric-light plant, where a natural shale-bottom pond is located close to the station. This plant consists of three water-tube boilers, of 265 horse-power each, and one 500-kilowatt steam turbine. There is also one small Corliss engine used for carrying the day load. An ordinary type of jet condenser is used, the discharge passing directly to the 14-inch header pipe from which the supply pipes for the sprays are taken. This is shown in Fig. 5. These supply pipes are 8 inches in diameter and are placed 20 feet apart. The 2-inch cross-pieces, each holding two spray nozzles, are 10 feet apart. As the cross-arms are 10 feet in length, a distance of 10 feet is maintained between the spray nozzles. Each main spray pipe is controlled by a valve, as shown. The header pipe is fitted with a stand-pipe near the side of the building, as seen in Fig. 6, which shows the piping in a temporary state.

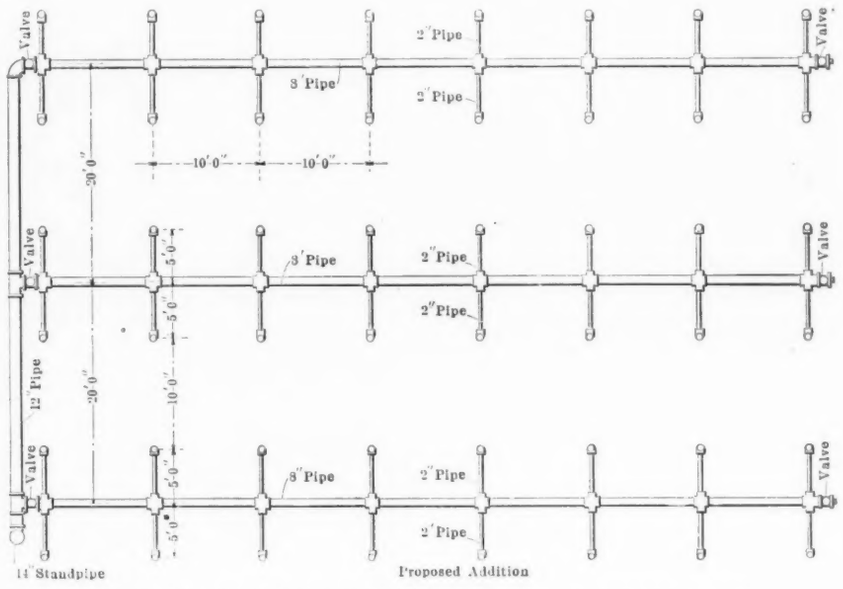


FIG. 5. DIAGRAM OF CONDENSING PIPING AT CLEVELAND PLANT

The nozzles used with this spray system are the "Simplex," made by the Uehling Instrument Company, Passaic, N. J. See Fig. 7. The spraying is produced by the impact of two streams of water striking each other at an angle of 90 degrees. It is said that the nozzles will operate well with a head as low as five pounds.

Another manner in which the spraying water can be handled is shown in Fig. 8. This system is installed at the plant of the Philadelphia Rapid Transit Company. In this instance the spray nozzles are placed between two of the car barns, the walls of which have been coveted with cement; the ground between, also cemented, is lower in the center, where a cold-water well has been located. The water flows from this well through a 20-inch pipe into another well which is made double, one half containing cold water. To each half of the well is piped an 8-inch centrifugal pump, one handling the warm water, the other the cold water in sufficient quantities to keep the condensing water down to a proper temperature. The discharge from these two pumps, which are shown in Fig. 9, passes to an eductor condenser, one of which is installed for each engine. The water from the condenser passes to a hot-well from which it is pumped to the spray nozzles. It will be seen from Fig. 7 that one section of the jets may be shut off in case they are not required.

In neither of the three installations described could the cost of operation be ascertained, as compared with that prevailing before the change was made.

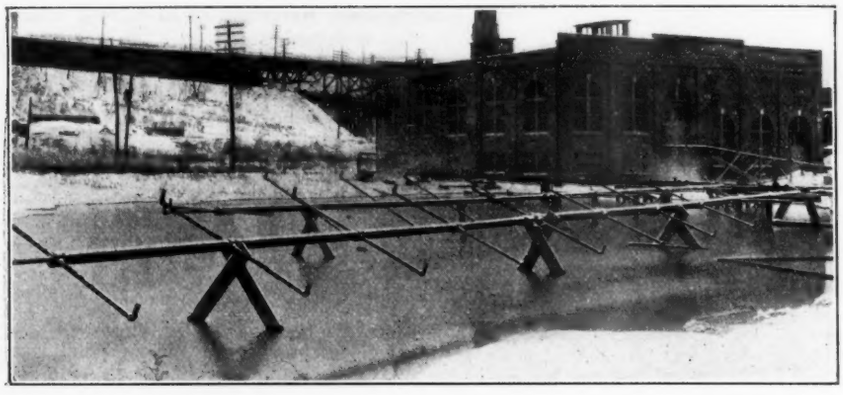


FIG. 6. THE PIPING IN TEMPORARY POSITION AT CLEVELAND

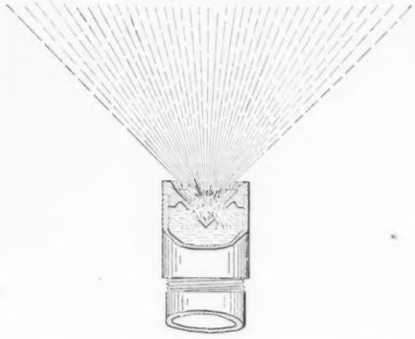


FIG. 7. "SIMPLEX" SPRAYING NOZZLE

In the case of the Delta installation, the saving in water amounted to practically nothing, there being a sufficient supply from the creek, the saving in this particular case being due to the higher vacuum carried for reasons already mentioned.

Supposing that the engineer in this case

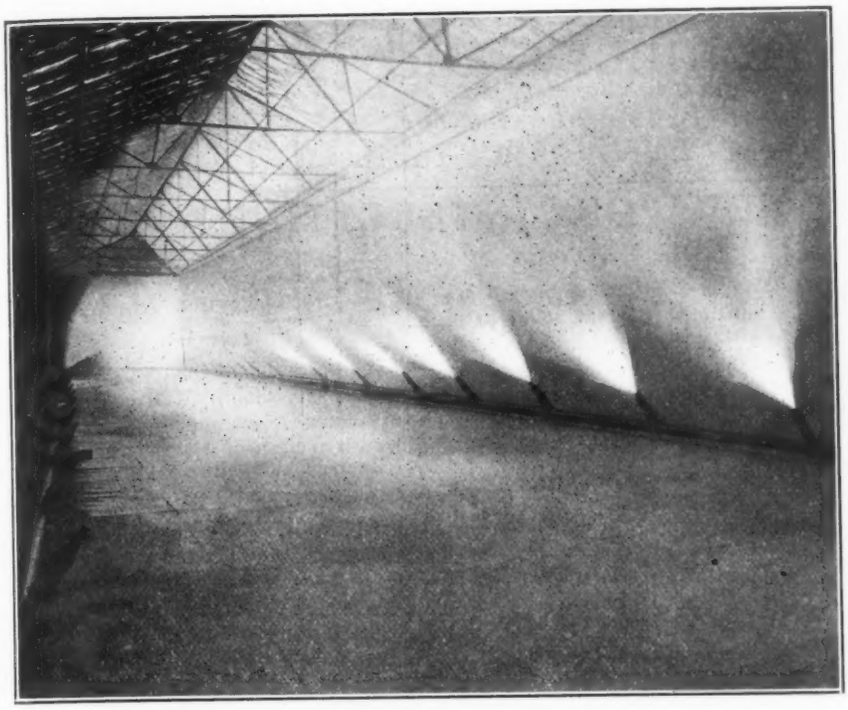


FIG. 8. SPRAY SYSTEM AT THE PHILADELPHIA RAPID TRANSIT COMPANY'S PLANT

required an evaporation of 30 pounds of water per horse-power per hour, and that the temperature of the water coming from the condenser averaged 110 degrees, the temperature of the condensing water being 66, then, according to past experience, the weight of water required to condense one pound of steam with these temperatures would be approximately 25 pounds. As the engine consumes 30 pounds of steam per horse-power per hour, the required amount of condensing water required would be $25 \times 30 = 750$ pounds, or 90 gallons per horse-power per hour. With an engine developing 650 horse-power the amount of condensing water required would be $650 \times 750 = 487{,}500$ pounds per hour. This is equivalent to 7800 cubic feet of water per hour for condensing water, which, at a cost of $1.50 per 1000 cubic feet, equals $11.70 per hour, or $117 per day of ten hours. Of course, such a cost would prohibit the use of a condenser, but the foregoing shows how an engine operating non-condensing can be changed over to condensing, by means of a spraying system for cooling the condensing water, the maintenance of the condensing water being a small item of expense, and that due to evaporation.

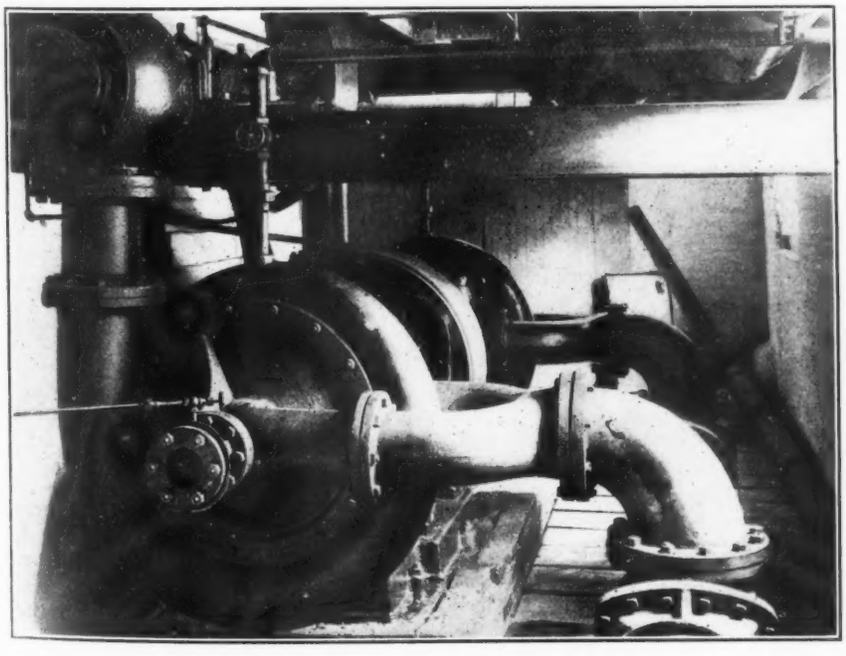


FIG. 9. SHOWING THE CENTRIFUGAL PUMPS

The Lubrication of Marine Engine Cylinders

By A. T. Rowe

Regarding the lubrication of marine-engine cylinders, my experience is that a vertical engine having a piston valve on the high-pressure cylinder will, and does, run as well without internal lubrication as with it. I have operated engines that had a piston valve on the high-pressure cylinder, or on the high-pressure and intermediate-pressure cylinders, both with and without internal lubrication, and could see no difference, except that in case of the engine using no internal lubrication the piston-rods had to be watched a little more closely to prevent heating.

As to using graphite for the purpose, it is sometimes added to the cylinder oil in the swabbing bucket, but I have never seen it introduced into the steam, although I do not see why it would not prove effective.

There is one thing in modern marine engines which I think could be adapted to stationary engines with considerable advantage, and that is the use of liners in the valve chests and cylinders.

The cylinders are cast of ordinary gray iron and fitted with liners of hard, close-grained cast iron. When the liner will stand no more re-boring it may be removed and a new one substituted.

The liner is flanged at the bottom and secured by bolts. It is free to move at the upper end and is made steam-tight at that end by a copper wire calked into an under-cut groove between the liner and cylinder, or by a gland and packing space. Of course, it adds somewhat to the initial cost of the cylinder, but makes the cylinder everlasting, and it is much cheaper to renew than a new cylinder would be, while it gives a good, hard wearing surface for the piston rings to bear on. Then, it may be removed after one light re-boring and the new liner put in, thus obviating the expense of a new piston. The liner is usually given a bearing at the top, at one or two points on the way down and at the bottom, and the spaces around it may be used as a steam jacket or not, as desired.

Possibly the hard, close-grained wearing surfaces may have something to do with the polish found in opening the cylinders. I have been with engines which had no means of putting oil into the cylinders except through the indicator pipes, which was necessary in the low-pressure cylinder upon starting up.

When belts slip, because of the dust in the room, they should be crossed; thus they will keep themselves clean. It will often be found that a number of belts can be crossed, the original direction of rotation being maintained by running a main belt straight.

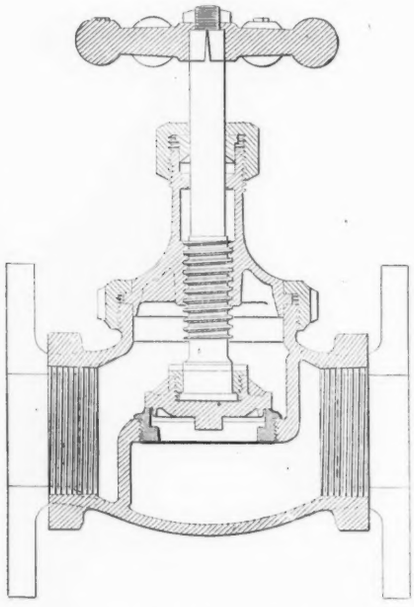
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

A New Lunkenheimer Valve Disk and Seat

A new valve disk and seat, designed by the Lunkenheimer Company, Cincinnati, O., is known as the "Renewo." The disk is provided with a projecting ring, which enters the valve-seat ring. It preserves the seat, as in entering the cylindrical part of the seat the disk deflects the current of steam from the seat-ring face, thus preventing the wire-drawing which would otherwise occur. This feature is especially



SECTIONAL VIEW OF "RENEWO" VALVE

important should the valve be left partly open for any length of time. The seating surface is kept free from scale and grit by the action of the thin current of steam discharged over it as the disk is brought home.

Another function of this ring is the prevention of water hammer which is caused by the sudden admission of steam. The seat is renewable and can be removed from the valve body by using a flat bar to engage the lugs on the inside of the ring. The seat may be re-ground a number of times before it is necessary to renew it. All other wearing parts, including the disk, can be renewed if necessary.

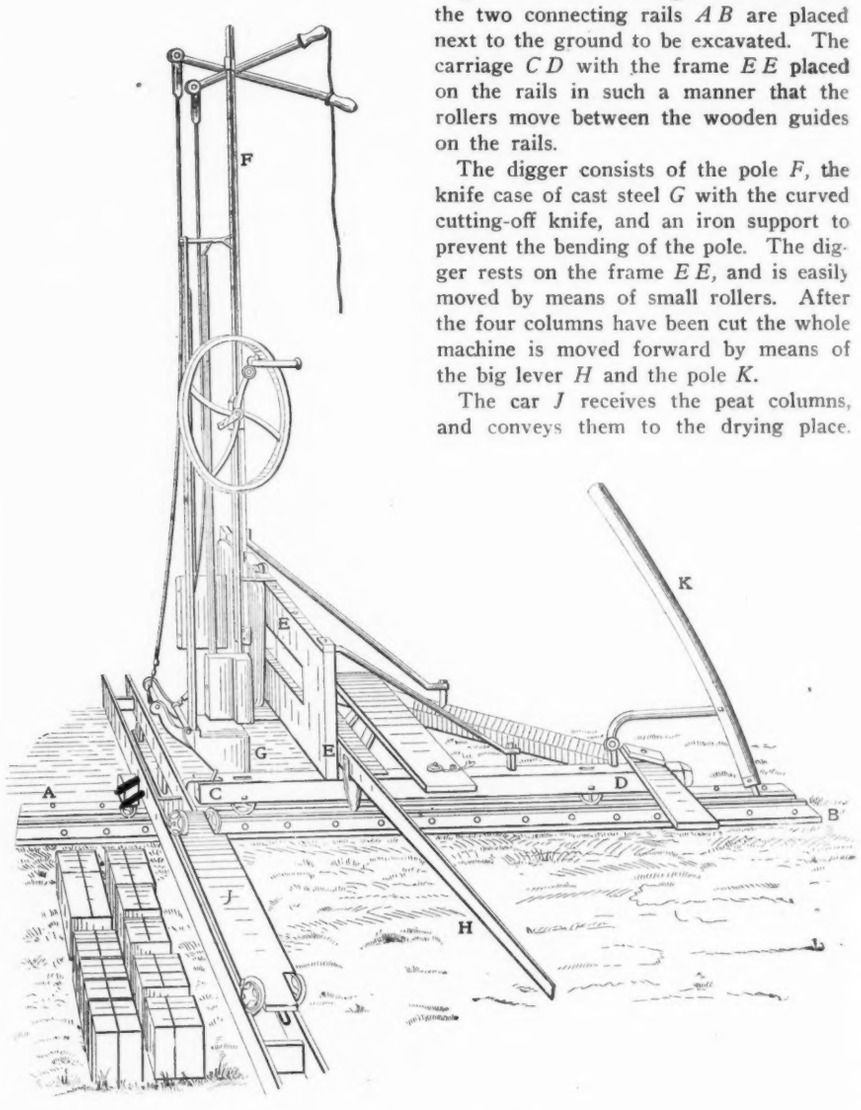
The hub is securely held to the body by means of a union ring, and the thread which holds the union to the body is protected at all times from the action of the steam, the joint being made between the flange on the hub and the neck of the body. This connection also acts as a tie or binder in screwing over the body, and tends to strengthen the valve. The stuffing-box can be re-packed under pressure when the valve is wide open, as a shoulder on the stem, directly above the threads, forms a seat beneath the stuffing-box. All valves above the ½-inch size have a gland follower in the stuffing-box.

Peat Digging Machine

The operation of this peat-digging machine is very simple. The machine moves from left to right and lifts the peat in a breadth of 4 feet from a depth of from 6 to 30 feet. After the bog has been cleared the two connecting rails *A B* are placed next to the ground to be excavated. The carriage *C D* with the frame *E E* placed on the rails in such a manner that the rollers move between the wooden guides on the rails.

The digger consists of the pole *F*, the knife case of cast steel *G* with the curved cutting-off knife, and an iron support to prevent the bending of the pole. The digger rests on the frame *E E*, and is easily moved by means of small rollers. After the four columns have been cut the whole machine is moved forward by means of the big lever *H* and the pole *K*.

The car *J* receives the peat columns, and conveys them to the drying place.



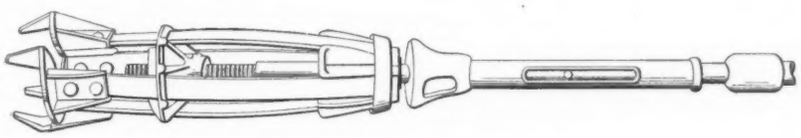
PEAT DIGGING MACHINE

The columns are cut in any convenient size, about 4-inch cubes, or smaller. It is said that two men will extract from 2000 to 3000 cubic feet per day.

This machine is being placed on the market by Julius Bordollo, Kingsbridge, New York City.

The "Faries" Tube Cleaner

This tube scraper is designed along lines which have been familiar to engineers for some years. It will enter the tube easily, is expanded when pushed forward and collapses when pulled backward. It may be adjusted to fit variations in the size of tubes by turning the handle in the scraper.



"FARIES" TUBE CLEANER

The ram feature is one not embodied in any other scraper. As illustrated, it consists of a slip joint; that is, the handle is fitted into a hollow section of tubing, slotted as shown, the handle having a pin driven through it, which limits the length of the slip joint. The object of this joint is to give ease of operation, especially when tight or uneven places in the tube are encountered. This joint admits of a limited withdrawal of the handle without moving the scraper, and which, when shoved forward quickly, gives a hammer or ramming action to the scraper. The device is manufactured by the Decatur Specialty Company, Decatur, Ill.

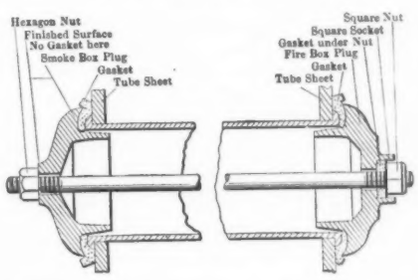
Blow-off Pipe Protector

This device for protecting the blow-off pipes of steam boilers consists of a covering of cast iron divided lengthwise, with ribs projecting inwardly, making an air space of about one-half inch between the pipe and sleeve. When the sleeve is run through the rear wall, or even part of the way, a small space is left open around the blow-off pipe and the draft inward causes air to pass in and through this space to the elbow, and prevents the pipe from getting much hotter than the temperature of the water it contains.

The sleeve can be removed and replaced at will for inspection of the pipe. It is fastened by a locking device inside, which is unlocked when either half of the sleeve is moved about an inch laterally. The elbow sleeve is constructed on the same principle, with ribs and an air space, and is fastened with keys in recesses. It can also be removed and replaced for inspection of joints at elbow. The construction of the protector sleeve and elbows is shown in the illustration. This protector is made by Edmund Mather, Second and Walnut streets, Harrisburg, Penn.

"Standard" Boiler Flue Plug

We herewith illustrate the Betterman "Standard" boiler-flue plug, manufactured by A. L. Smith & Co., 228 N. Clarion street, Philadelphia. It consists of two caps, clamped to the tube by means of a rod and two nuts. A tight joint between the plug and the boiler head is made by means of gaskets, as shown in the illustration. With the plug in position, the nuts are tightened up and the boiler is then in condition to operate. It will be seen that the fire-box end has a square socket in which a square nut is placed. The smoke-box plug has a hexagon nut to facilitate tightening. The simplicity of the plug means a quick repair, and the ease of action and the perfect adjustment enables the user to repair a burst tube in a very short time.

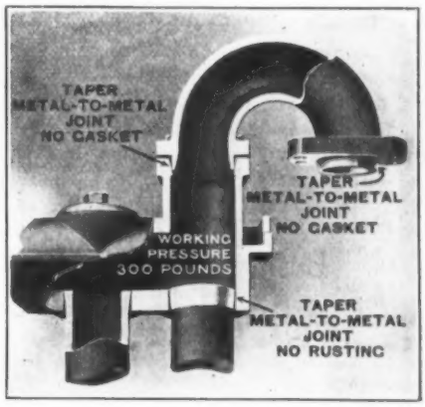


"STANDARD" BOILER PLUGS AS APPLIED TO A TUBE

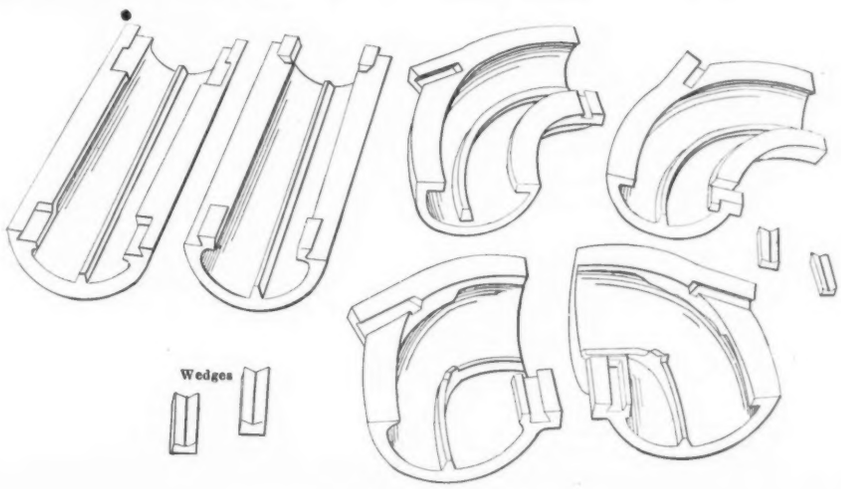
An Improved Economizer Joint

The difficulty encountered in economizer joints due to leaky gaskets is believed to be overcome in the Sturtevant design of economizer by making every joint taper metal-to-metal, thus eliminating gaskets. On a test with the metal-to-metal joint the economizer showed no signs of leakage up to 300 pounds per square inch of pressure. Whenever it is necessary to replace a pipe, cap or header, the operation is performed with ease with such joints, as the joints are quickly made or broken.

The accompanying illustration shows header and elbow connection, also the sectional views of a portion of the top parts forming the tapered metal-to-metal joints. This joint is manufactured by the B. F. Sturtevant Company, Hyde Park, Mass.


TAPER METAL-TO-METAL JOINT NO GASKET
TAPER METAL-TO-METAL JOINT NO GASKET
WORKING PRESSURE 300 POUNDS
TAPER METAL-TO-METAL JOINT NO RUSTING

METAL-TO-METAL JOINT



HALF SECTIONS OF SLEEVE AND ELBOWS

About the only manhole gasket that can be used repeatedly with safety is a flat-wire inserted asbestos gasket. As marking the manhole plate for the purpose is impracticable, it can be done successfully as follows: Leave the gasket adhering to the plate, and do not turn the plate end for end; put the plate in place and tighten the nut with thumb and finger while working the plate until it settles into its proper place, which can be felt. Then a wrench may be applied.

The average velocity of chimney gases is 600 feet per minute.

Examination Question on Indicator Diagrams—Correction

In A. C. Waldron's letter, "Examination Question on Indicator Diagrams," published in the June 30 number, there occurred two errors for which Mr. Waldron was not to blame. On page 1037, in the middle column, second line from the bottom, the first word should have been "or" instead of "on." On the same page, third column, third line from the top, the word "expansion" was used instead of "compression."

Personal

John Van Brunt, a graduate of both Cornell and Stevens, who has been with the American Stoker Company for ten years, has been appointed chief engineer of that company.

George W. Heald, for the past three and a half years mechanical engineer and chief draftsman for the Bates Machine Company, Joliet, Ill, has opened an office, as consulting and constructing mechanical engineer, in the Old Colony building, Chicago.

A. Bement, of Chicago, whose writings upon combustion and kindred subjects have made his name familiar to our readers, has removed from 125 Monroe street to the Fisher building, where he will continue to practice as a consulting, mining and mechanical engineer.

Business Items

A series of monthly calendars depicting child life in Holland are being distributed by the Dubois Iron Works, Dubois, Penn.

George H. Moseman has been appointed manager of the American Stoker Company's New England office at 176 Federal street, Boston, Mass.

The patents of the Edwards metallic packing, together with the rights to manufacture, etc., have been purchased by the D. H. C. Company, Inc., 95 Liberty street, New York City.

John C. Mohr, 4327 Lake avenue, Chicago, manufacturer of boiler gaskets, reports a recent contract which includes the equipment of forty boilers belonging to the Commonwealth-Edison Company, of Chicago, with Mohr's elastic metal asbestos gaskets.

The Western Electric Company, of Chicago, has acquired the rights of manufacture and sale of the Rateau turbine, and commencing with July 1 is ready to accept orders for units of any capacity. The company has built several turbines of this type to the order of the Rateau interests in America, and is therefore well equipped in experience, as well as in plant and machine-shop facilities to develop this type of turbine in this country.

The works of the American Stoker Company, at Erie, Penn., were destroyed by fire on June 1, occasioning great loss. With admirable enterprise the company immediately secured new accommodations at Monongahela, Penn., in the works of the Coshocton Iron Company, and, having saved its drawings, had new patterns made to replace those which were burned, and within 30 days shipped 16 sets of stokers complete. It announces that its customers have not been, nor will be, inconvenienced on account of the fire.

The Cutler-Hammer Mannfacturing Company, of Milwaukee, maker of electric controlling devices, has just completed arrangements whereby it will be represented on the Pacific Coast by Otis & Squires, of 111 New Montgomery street, San Francisco. A large stock of standard Cutler-Hammer controllers will be carried by Otis & Squires, enabling them to make prompt delivery of apparatus. A. W. Vinson, who has for several years been connected with the engineering department of the Cutler-Hammer Manufacturing Company, has been transferred to the office of Otis & Squires, where his services will be available to those confronted with problems of electric control which cannot be met by the use of standard apparatus.

New Equipment

The Hartford City (Ind.) Light Company is planning to install new dynamos.

The citizens of Holly, Colo., voted to issue $10,000 bonds for a water-works system.

City of East Point, Ga., will vote on issuance of $15,000 bonds for electric-light plant.

The city of Wetumka, Okla., has voted $25,000 bonds to construct light and water plant.

W. C. Newman, Atlee, Va., contemplates establishing an ice plant of six-ton capacity.

The city council of Cuero, Texas, is investigating the proposition of installing a lighting plant.

The city of Rising Star, Texas, has voted bonds or construction of water works and lighting plant.

The Packard Motor Car Company, Detroit, Mich., is contemplating increasing its power plant.

P. A. Fitzhugh, of Clinton, La., will erect a $100,000 cottonseed-oil mill at Waurika, Okla.

The Hamman-Bessonnette Company, Temple, Texas, contemplates establishing a cold-storage plant.

The Nants Cold Storage Company, Paris, Tenn., will erect a three-story cold-storage building.

The city of Clinton, La., contemplates the establishment of an electric-light plant and an ice plant.

It is stated that the output of the municipal electric-light plant at Williston, N. D., will be increased.

The Eclipse Feed Water Heater and Purifier Company, of Appleton, Wis., will move its plant to Oshkosh.

Plans have been filed for an eight-story printing house for Edward Stern & Company, Philadelphia, Penn.

The citizens of Nowata, Okla., voted to issue $65,000 bonds for the purpose of installing a water system.

The Joseph Schlitz Brewing Company, Milwaukee, Wis., will install a cold-storage plant at Richmond, Va.

The Mitchell (S. D.) Power Company has bought site for a new plant. About $50,000 will be expended.

The City Council, Springfield, Ohio, is considering the question of establishing a municipal electric-light plant.

The Westport (Conn.) Water Company, furnishing water and electricity, contemplates increasing its output.

The city of Fairview (Okla.) contemplates voting on issuing bonds to install water-works and electric-light plant.

The Michigan Power Company, Lansing, Mich., is said to have purchased additional property for sub-stations.

The Georgetown (Texas) Water and Electric Light Company will expend $25,000 in improvements. C. S. Hale, manager.

The Birmingham (Ala.) Railway, Light and Power Company will erect a plant in Jonesville. Cost about $1,500,000.

The city of St. Petersburg, Fla., will vote on the issuance of $7000 bonds to purchase steam pump for water works.

The Brightwood Manufacturing Company, Lawrence, Mass., has awarded contract for the erection of a new boiler house.

The United States Coal and Oil Company, of Holden, W. Va., it is reported contemplates building a railroad 125 miles long.

The city of Sapulpa, Okla., proposes to issue $35,000 bonds for extending water system and $10,000 for equipping fire department.

The Sargeant Manufacturing Company, Charlotte, N. C., recently incorporated, will erect cotton mill to be operated by electricity.

The St. Pauls (N. C.) Cotton Mill Company will begin erection of mill for manufacturing cotton yarns. Electric power will be used.

Plans will be received until July 16 by the Construction Quartermaster, Fort Dade, Fla., for the construction of a distilling and ice plant.

The Suburban Land and Power Company, Durham, N. C., has been incorporated to build an electric light and water plant. E. J. Parrish, president.

The Board of Public Affairs, Plymouth, Ohio, is said to be considering the question of installing another gas engine in the municipal electric-light plant.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Thoroughly competent packing salesmen. Box 81, POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Salesmen on commission for New England, Southern and Western States for high grade shaking grates. Box 13, POWER.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—Salesman on commission for high grade power specialties. Address, stating experience, Chas. T. Luce Co., 160 Congress St., Boston, Mass.

WANTED—Master mechanic for iron mine in northern Michigan. Must have had good experience with all kinds of mine machinery and machine shop work. To an energetic, capable man a good position is offered. If requested communications will be confidential. Address "Iron," care of POWER, giving experience in detail, references, and pay expected.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION wanted by technical graduate with five years' practical erecting experience for large water tube boiler company. Prefer position in shops or sales. Box 11, POWER.

FIREMAN, married, sober and steady, high pressure, hard or soft coal, wants position. First class New York City references. Address Alfred G. Bunker, Box 21, Echo, N. Y.

ENGINEER will pay $50.00 commission to anyone who secures or helps him secure a position as engineer, assistant engineer or station man in Rocky mountains or West. Box 14, POWER.

COMMERCIAL ENGINEER, 18 years' experience, steam, gas, electric machinery, would represent manufacturer New York. Manager, sales manager, electrical, mechanical lines. Any location. Box 12, POWER.

POSITION WANTED—In power house by young man, 26. Ohio license; four years' experience with Buckeye and Corliss engines; complete course I. C. S. At present student in

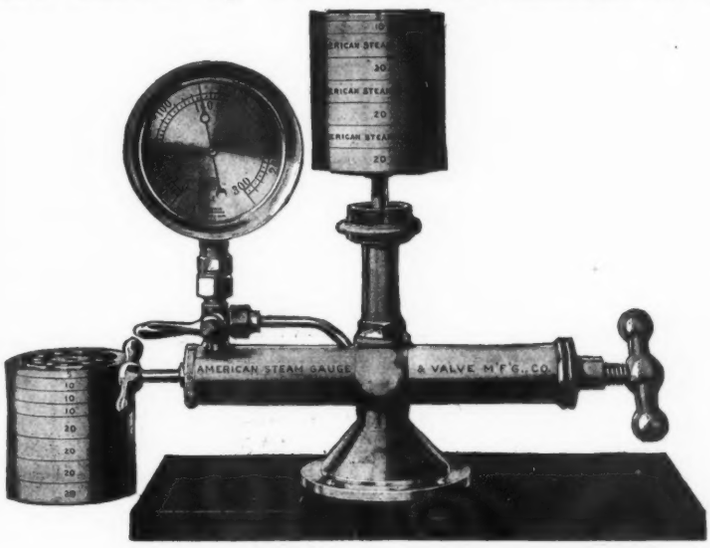
Is Your Steam Gauge Guessing?

If so, and it isn't perfectly accurate, there's a leakage in your plant, and a loss where there should be a gain.

You can stop that guessing immediately with

The American Dead Weight Gauge Tester

Operated by dead weights, it occupies but little space and has all the advantages of the mercury column. Inaccurate gauges are shown up at once and immediate correction made possible.



Test Gauges are done away with and the necessity of sending them to the manufacturer frequently for readjustment is eliminated. By using the "American" Dead Weight Gauge Tester you can be sure of gauge accuracy—and that means steam and fuel economy.

ASK FOR CIRCULAR 4-D.

American Steam Gauge & Valve Mfg. Co.

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. Atlanta, 853 Equitable Bldg. Chicago, 7-9 So. Jefferson St.

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Montreal, 444 St. James Street.
San Francisco, 247 Pine Street.
Los Angeles, 213 So. Los Angeles Street.

Ohio Northern University. Address "I. R. R.," 118 So. Main St., Ada, Ohio.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

ALL PRACTICAL ENGINEERS should apply to Wm. O. Webber, Consulting Engineer, 432 Exchange Bldg., Boston, for information concerning tables on all engineering subjects.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-Examiner U. S. Patent Office, 4 Dietz Bldg., Washington, D. C.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Buckeye engine, 150 to 175 h. p., good as new, great bargain for cash. Can be seen in operation. Address No. 1001 Arcade Bldg., Philadelphia, Pa.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—The patent rights of one of the best steam traps and oil filters manufactured. A bargain if sold quickly. Parties reason for selling being the desire to retire from business. Box 85, POWER.

FOR SALE—Territory rights to manufacture a metallic packing with an established reputation. Highly recommended by all users. Equipment costs very little. Excellent opportunity for hustlers in all manufacturing districts. Very favorable terms. Also own foreign patents. Box 7, POWER.

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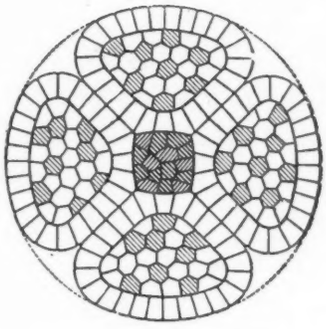
"AMERICAN"

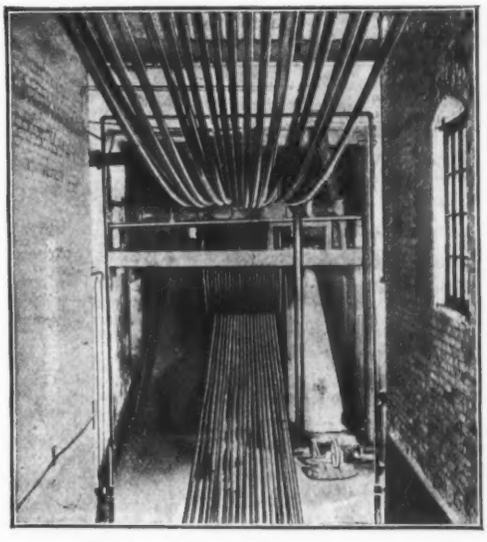


"Like Smooth Rods of Iron"

"American" Transmission Rope in service soon assumes an almost perfectly rounded smooth surface. The graphite lubricant with which the internal yarns and core are saturated, permeates every fibre, facilitating the compression of the strands until the rope becomes smooth and round and presents the greatest area of contact to the sheave groove.

"American" Ropes are designed to turn in their grooves keeping the rope round and smooth and the grooves of the sheaves perfectly true.

If you desire complete information regarding the advantages of rope driving and "American" Transmission Rope, write for a copy of our "Blue Book of Rope Transmission." Copies free.



The American Manufacturing Co.,

128 65 Wall Street, New York City.

TRANSMISSION ROPE

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Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N.J.
Rhoads & Son, J. E., Phila., Pa.
Shultz Belting Co., St. Louis, Mo.
Stephenson Mfg. Co., Albany, N. Y.
Walton Co., F. S., Philadelphia, Pa.

Belt Fasteners

Bristol Company, The, Waterbury, Conn.

Belt Lacing

Bristol Co., The, Waterbury, Conn.

Benders, Hydraulic

Watson-Stillman Co., New York.

Bends, Wrought Iron Pipe

Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Pittsbusgh Gage and Supply [Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Blowers

Beggs & Co., Jas., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Green Fuel Economizer Co., Matteawan, N. Y.
McClave-Brooks Co., Scranton, Pa.
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Blowers, Furnace

McClave-Brooks Co., Scranton, Pa.

Boiler Door Arches

McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Boiler Feeders

American Steam Pump Co., Battle Creek, Mich.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Lunkenheimer Co., Cincinnati, O.
Myers & Bro., F. E., Ashland, O.
National Steam Pump Co., Upper Sandusky, O.
Pittsburg Gage & Supply Co., Pittsburg, Pa.
Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Boiler Fittings

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Boiler Skimmers

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Boilers, Second Hand

Wickes Boiler Co., Saginaw, Mich.

Boilers, Tubular

Babcock & Wilcox Co., New York.
Beggs & Co., Jas., New York.
Edge Moor Iron Co., Edge Moor, Del.
Franklin Boiler Works Co., Troy, N. Y.
Griffith & Wedge Co., Zanesville, O.
Heine Safety Boiler Co., St. Louis, Mo.
Keeler & Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Oil Well Supply Co., Oswego, N. Y.
Phoenix Iron Wks., Meadville, Pa.
Robb-Mumford Boiler Co., Amherst, N. S.
Struthers-Wells Co., Warren, Pa.
Tudor Boiler Co., Cincinnati, O.
Vilter Mfg. Co., Milwaukee, Wis.
Wetherill & Co., Robert, Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Boilers, Water Tube

Babcock & Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor, Del.
Franklin Boiler Works, Troy, N. Y.
Heine Safety Boiler Co., St. Louis, Mo.

Boilers, Water Tube—*Cont.*

Keeler Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Morrin Climax Boiler Co., Brooklyn, N. Y.
Oil Well Supply Co., Oswego, N. Y.
Parker Boiler Co., Philadelphia, Pa.
Rust Boiler Co., Pittsburg, Pa.
Struthers-Wells Co., Warren, Pa.
Vogt Machinery Co., Henry, Louisville, Ky.
Wetherill & Co., Robt., Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Books, Technical

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Text Book Co., Scranton, Pa.

Building Materials, Fireproof

Carey Co., The, Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.

Castings, Brass and Iron

Homestead Valve Mfg. Co., Pittsburg, Pa.
McClave-Brooks Co., Scranton, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Castings, General

Neemes Bros., Troy, N. Y.

Castings, Malleable

Jeffrey Mfg. Co., Columbus, O.

Cement, Asbestos

Johns-Manville Co., H. W., New York.
N. Y. Belting & Packing Co., New York.

Cement, Boiler

Smooth-On Mfg. Co., Jersey City, N. J.

Chain Blocks

Yale & Towne Mfg. Co., New York.

Clamps, Steam Joint

McCrea & Co., James, Chicago, Ill.

Cleaners, Boiler Tube

Buckeye Boiler Skimmer Co., Toledo, Ohio.
Monarch Steam Blower Co., Troy, N. Y.
Garlock Packing Co., Palmyra, N. Y.
General Specialty Co., Buffalo, N. Y.
Stewart Heater Co., Buffalo, N. Y.

Clocks, Engine Room

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Clutches, Friction

Williams Fdry. & Mach. Co., Akron, Ohio.

Coal and Ash Handling Machinery

Bartlett & Snow Co., C. O., Cleveland, O.
Jeffrey Mfg. Co., Columbus, O.

Cocks, Blow-Off

Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Cocks, Gauge

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Huyette Co., P. B., Philadelphia, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Reliance Gauge Column Co., Cleveland, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cocks, Steam

Homestead Valve Mfg. Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Compound, Boiler

Bird-Archer Co., New York.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Dearborn Drug & Chemical Co., Chicago, Ill.
Hawk-Eye Compound Co., Chicago, Ill.
Johns-Manville Co., H. W., New York.

Compound, Lubricating

Cook's Sons, Adam, New York.

Condensers

Alberger Condenser Co., New York.
American Steam Pump Co., Battle Creek, Mich.
Baragwanath & Son, Wm., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Union Steam Pump Co., Battle Creek, Mich.
Wheeler Condenser and Engineering Co., New York.

Condensers, Gas

Phoenix Iron Wks., Meadville, Pa.

Consumers, Smoke

Climax Smoke Preventer Co., Boston, Mass.

Controllers, Electric

General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa

Cooling Towers

Alberger Condenser Co., New York.
Baragwanath & Sons, Wm., Chicago, Ill.
Wheeler Condenser and Engineering Co., New York.

Cordage

American Mfg. Co., New York.

Correspondence Schools

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa,

Couplings, Clutch

Williams Fdry. & Mach. Co., Akron, Ohio

Covering, Pipe and Boiler

Carey Co., The Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.
U. S. Mineral Wool Co., New York.

Cranes

Yale & Towne Mfg. Co., New York.

Die Stocks

Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.

District Steam Heating

American District Steam Co., Lockport, N. Y.

Draft, Mechanical

Green Fuel Economizer Co., Matteawan, N. Y.

Drills, Upright

Barnes Co., W. F. & Jno., Rockford, Ill.

Dynamos and Motors, Alternating Current

C & C Electric Co., The, New York.
Clark Bros. Co., Belmont, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Dynamos and Motors, Direct Current

C & C Electric Co., The, New York.
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.

Dynamos and Motors, Direct Current—*Continued.*

Northern Electrical Mfg. Co., Madison, Wis.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Economizers, Fuel

Green Fuel Economizer Co., Matteawan, N. Y.

Ejectors

Beggs & Co., Jas., New York.
Desmond-Stephan Mfg. Co., Urbana, Ohio.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.

Electrical Engineers

Crocker-Wheeler Co., Ampere, N. J.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Northern Electrical Mfg. Co., Madison, Wis.

Electrical Supplies

General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Ohio Brass Co., Mansfield, Ohio.

Engineers' Supplies

Mound Tool & Scraper Co., St. Louis, Mo.

Engines, Corliss

Bates Machine Co., Joliet, Ill.
Beggs & Co., Jas., New York.
Cooper Co., C. & G., Mt. Vernon, O.
Griffith & Wedge Co., Zanesville, O.
Ide & Son, A. L., Springfield, Ill.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Providence Eng. Works, Providence, R. I.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Watertown Engine Co Watertown, N. Y.
Wetherill & Co., Robert, Chester, Pa.

Engines, Gas and Gasolene

Alberger Co., A. H., Buffalo, N. Y.
De La Vergne Machine Co., New York.
Du Bois Iron Works, Du Bois, Pa.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, High Speed

American Diesel Engine Co., New York.
American Engine Co., Bound Brook, N. J.
Ball Engine Co., Erie, Pa.
Bates Machine Co., Joliet, Ill.
Clark Bros. Co., Belmont, N. Y.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Eng. Co., Fitchburg, Mass.
Ide & Son, A. L., Springfield, Ill.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Phoenix Iron Works, Meadville, Pa.
Reeves Engine Co., Trenton, N. J.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Philadelphia, Pa.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.

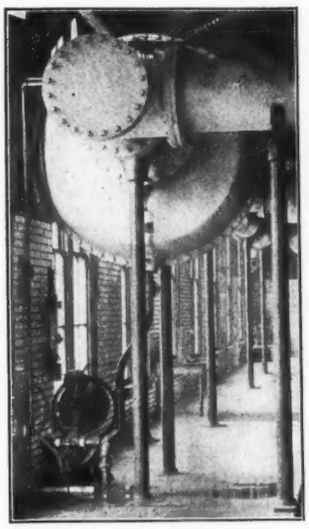
Engines, Medium and Low Speed

American Diesel Engine Co., New York.
Ball Engine Co., Erie, Pa.
Brown Engine Co., C. H., Fitchburg, Mass.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Ide & Son, A. L., Springfield, Ill.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Reeves Engine Co., Trenton, N. J.
Shepherd Engineering Co., Williamsport, Pa.

COCHRANE SEPARATORS

WHERE SEPARATORS PAY

It pays to remove all water (moisture, spray or mist) from live steam, and moisture and oil from exhaust steam. Whether wet or dry makes little difference with one cylinderful of steam, but figure on millions of cylindersful,—and it's quite a BIG ITEM. Then, this water left in the steam nibbles away a good deal of the cylinder oil in the course of a year,—and that's an ITEM—again. And, if the oil is washed away there is more wear and friction, a third item. So it is quite apparent that a steam separator will pay handsomely, providing it's a good one; the cheap ones give from 50% to perhaps 90%, but a Cochrane gives practically perfect separation. It makes a greater saving and keeps out the extra water that does its share of cylinder heat-robbing.



One break-down of an engine or turbine, caused by priming of the boilers, or accumulated condensation in the steam pipe might cost more than ten separators. Sometimes steam as delivered is 40% water by weight.

If you wanted proof regarding the thoroughness of the Cochrane Separators, you've got it in the access of the Cochrane Oil Separator.

Exhaust steam is worth as much in feed water heaters, drying coils, radiators, calendering rolls, etc., as live steam at the same temperature, that is, if you have taken the oil out with a Cochrane Separator; and when you have done this, the steam after condensation can be fed back to the boilers again as pure distilled water which will deposit no scale, cause no corrosion and require no purification.

Cochrane Separators are useful for stopping chips, grit, packing, etc., to keep water out of superheaters, to provide dry steam for whistles, to remove moisture from compressed air and to clean gas of tar and soot.

In succeeding advertisements we wish to tell you *just what Cochrane Separators will do*, how well they do it, how much they save, and why they are able to do it better than other separators. It is only necessary to compare other Separators with the Cochrane, point by point, as we shall do, to see why a Cochrane removes all water and oil while other separators are partial or complete failures.

If you don't wish to wait for succeeding advertisements, write for our book "15-S" at once, in which all sides of the subject are fully presented.

HARRISON SAFETY BOILER WORKS,
17TH. & CLEARFIELD STS., PHILADELPHIA, PA.

TALK I

Engines, Medium and Low Speed—*Continued.*

Skinner Engine Co., Erie, Pa.
Southwark Foundry & Mach. Co., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Oil

American Diesel Engine Co., New York.
De La Vergne Machine Co., New York.

Engines, Rotary

Ball-Cooley Engineering Co., New York.

Exhaust Heads

Burt Mfg. Co., Akron, O.
Gardner Gov. & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Ohio Blower Co., Cleveland, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Experts, Chemical

Hunt & Co., Robt. W., Chicago, Ill.

Fans, Electric

Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Triumph Electric Co., Cincinnati, O.
Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

Fans, Exhaust and Ventilating

Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.

Fans, Mine Vetilating

Jeffrey Mfg. Co., Columbus, O.

Feed Water Filters

Beggs & Co., Jas., New York.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Keystone Chemical Co., Philadelphia, Pa.
Northern Water Softener Co., Madison, Wis.

Feed Water Heaters and Purifiers

Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Bates Machine Co., Joliet, Ill.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Erie Mfg. & Supply Co., Erie, Pa.
Goubert Mfg. Co., New York.
Griscom-Spencer Co., New York.
Harrison Safety Boiler Wks., Philadelphia, Pa.
Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill.
Loew Mfg. Co., Cleveland, O.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., F. L., New York.
Phoenix Iron Wks., Meadville, Pa.
Stewart Heater Co., Buffalo, N. Y.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser and Engineering Co., New York.
Whitlock Coil Pipe Co., Hartford, Conn.
Wickes Boiler Co., Saginaw, Mich.

Files and Rasps

Barnett & Co., G. & H., Akron, O.

Filters, Oil

Burt Mfg. Co., Akron, O.
Liberty Mfg. Co., Pittsburg, Pa.
Pittsburg Gage & Supply Co., Pittsburg, Pa.

Fire Brick

McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Fittings, Hydraulic

Watson-Stillman Co., New York.

Fittings, Pipe

Triumph Ice Machine Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, O.

Flanges

Central Station Steam Co., Detroit, Mich.

Flange Fittings, High or Low Pressure

Lunkenheimer Co., Cincinnati, O.
Pittsburg Gage & Supply Co., Pittsburg, Pa.
Pittsburg Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Floats

Anderson Co., V. D., Cleveland, O.
Reliance Gauge Column Co., Cleveland, O.

Furnaces

Continental Iron Works, Brooklyn, N. Y.
Murphy Iron Works, Detroit, Mich.

Furnaces, Smokeless

McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Penn.

Gaskets

American Goetze Gasket & Packing Co., New York.
Brandt, Randolph, New York.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
N. Y. Belting & Packing Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Smooth-On Mfg. Co., Jersey City, N. J.
U. S. Mineral Wool Co., New York.

Gaskets, Copper

Central Station Steam Co., Detroit, Mich.
Restein Co., Clement, Philadelphia, Pa.
U. S. Mineral Wool Co., New York.

Gauge Testing Outfit

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gauges

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.
Huyette Co., Paul B., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburg Gage & Supply Co., Pittsburg, Pa.

Gauges, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gauge Glasses

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.

Gauges, Pressure

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Gauges, Recording

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Gauges, Vacuum

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Gauges, Water

Ohio Brass Co., Mansfield, O.

Generating Sets

American Engine Co., Bound Brook, N. J.
Crocker-Wheeler Co., Ampere, N. J.
C. & C. Electric Co., New York.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Generating Sets—*Continued.*

Watertown Engine Co., Watertown, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Governors, Inertia

Ide & Son, A. L., Springfield, Ill.

Governors, Pump

Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Indianapolis, Ind.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Gardner, Governor & Separator Co., Quincy, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.

Graphite

Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.

Grates

Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.

Grates, Clinker Cutting

Neemes Bros., Troy, N. Y.

Grates, Shaking and Dumping

McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.

Grates, Stationary

Neemes Bros., Troy, N. Y.

Grease

Cook's Sons, Adam, New York.
Keystone Lubricating Co., Philadelphia, Pa.

Heating and Ventilating Apparatus

Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Webster & Co., Warren, Camden, N. J.

Hose, Air and Oil

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Hose, Steam and Water

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Indicators, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Gas Engine

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Hydraulic

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Speed

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Starrett Co., L. S., Athol, Mass.

Indicators, Steam Engine

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, James L., New York.

Indicators, Steam Engine—*Continued.*

Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Trill Indicator Co., Corry, Pa.

Injectors

American Injector Co., Detroit, Mich.
Desmond-Stephan Mfg. Co., Urbana, Ohio.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Mach. Co., Cincinnati, O.
Schutte & Koerting Co., Philadelphia, Pa.

Insulation

Johns-Manville Co., H. W., New York.

Jacks, Hydraulic

Watson-Stillman Co., New York.

Joints, Expansion

Central Station Steam Co., Detroit, Mich.

Lamps, Arc and Incandescent

Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Locks

Yale & Towne Mfg. Co., New York.

Lubricants

Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Philadelphia, Pa.

Lubricators

Cook's Sons, Adam, New York.
Detroit Lubricator Co., Detroit, Mich.
Greene, Tweed & Co., New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Lubricator Co., Wadsworth, O.
Philadelphia Lubricator & Mfg. Co., Philadelphia, Pa.

Machinery, Conveying

Bartlett & Snow Co., C. O., Cleveland, O.
Jeffrey Mfg. Co., Columbus, O.

Machinery, Crank Pin Turning

Underwood & Co., H. B., Philadelphia, Pa.

Machinery, Ice and Refrigerating

De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.
Vilter Mfg. Co., Milwaukee, Wis.
York Mfg. Co., York, Pa.

Machinery, Second Hand

Randle Mach. Co., Cincinnati, O.

Machines, Portable Milling

Underwood & Co., H. B., Philadelphia, Pa.

Machines, Valve Reseating

Leavitt Mach. Co., Orange, Mass.

Mats and Matting

Mercer Rubber Co., Hamilton Square, N. J.

Mechanical Draft Apparatus

Green Fuel Economizer Co., Matteawan, N. Y.

Mechanical Stokers

Westinghouse Machine Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Pa.

Meters, Steam

St. John, G. C., New York.

Meters, Water

Blake Mfg. Co., Geo. F., New York.

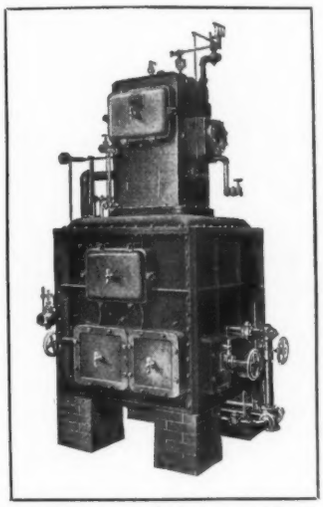
Metal Polish

Hoffman, Geo. W., Indianapolis, Ind.

Oil Burners

Hammel Oil Burner Co., Los Angeles, Cal.

Prescription Without Diagnosis Is Useless



WEBSTER CHEMICAL PURIFIER

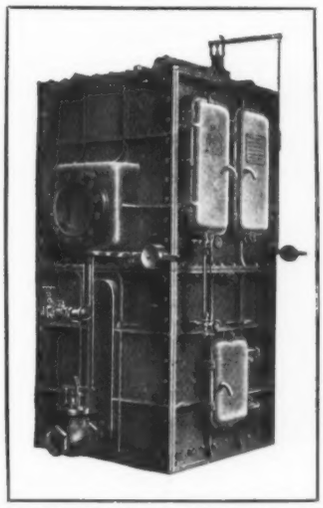
There's no one Feed Water Heater, Purifier and Filter made that will exactly satisfy all conditions in all plants.

Some may "cover a multitude of sins", but the Heater that covers them all and gives best results must be adapted to individual requirements.

We do not prescribe any one of the Webster Heaters for all conditions. We want to get a "diagnosis" of your needs. We have expert engineers ready to study your case and prescribe the Webster Heater that will give you the best possible results. Then we can guarantee that Heater absolutely.

In general we can say that our Heaters will save you coal and water—more than any others on the market. But you want to know *how much*—and that's exactly what we want to tell you.

Write us for full information. Let us specialize on your case. Booklet 12-F is free.



WEBSTER FEED-WATER HEATER, PURIFIER AND FILTER

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Carey Co., The Philip, Cincinnati, O.
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Eureka Packing Co., New York.
Garlock Packing Co., Palmyra, N. Y.
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Garlock Packing Co., Palmyra, N. Y.
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Underwood & Co., H. B., Philadelphia, Pa.
Vanda Co., New York.

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National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

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Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., The, Cleveland, O.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

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Pittsburg Valve, Foundry & Construction Co., Pittsburg, Pa.
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Borden Co., Canton, O.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., The, Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, O.
Trimont Mfg. Co., Roxbury, Mass.
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Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.

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Jeffrey Mfg. Co., Columbus, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Saginaw Mfg. Co., Saginaw, Mich.

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Watson-Stillman Co., New York.

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Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Westinghouse Mach. Co., Pittsburg, Pa.

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Hill Publishing Co., New York.
International Correspondence Schools, Scranton, Pa.

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Saginaw Mfg. Co., Saginaw, Mich.

Pulleys, Clutch

Williams Fdry. & Mach. Co., Akron, Ohio.

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Wheeler Condenser & Engineering Co., New York.

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Blake Mfg. Co., Geo. F., New York.
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Pittsburg Gage & Supply Co., Pittsburg, Pa.
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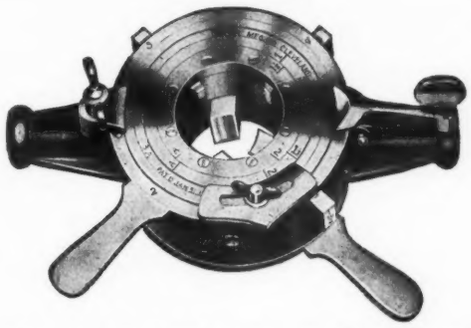

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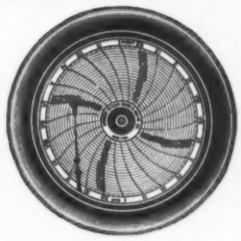

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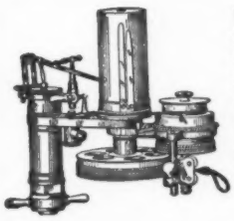

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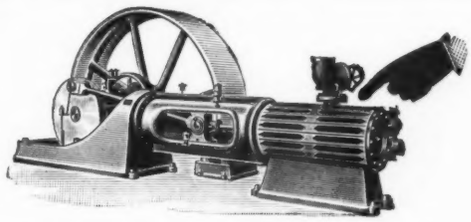

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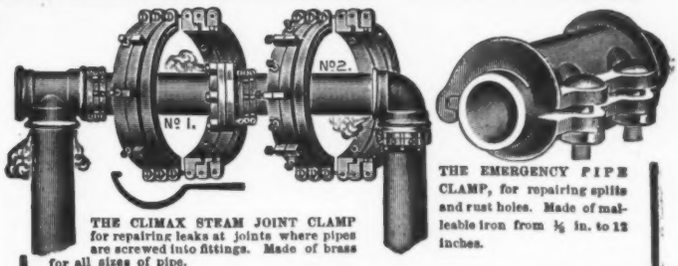

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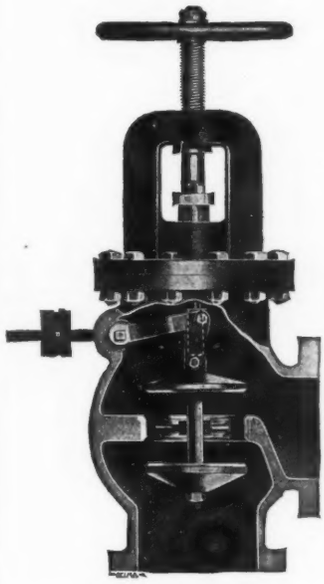

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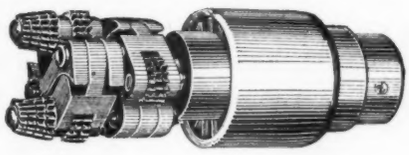

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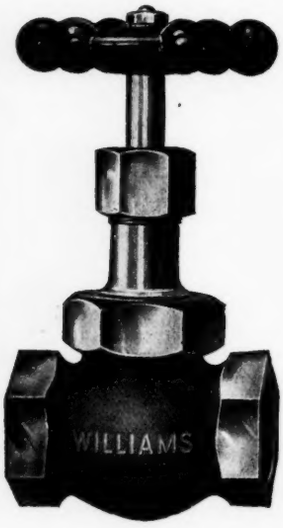

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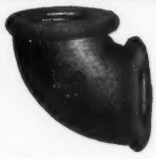

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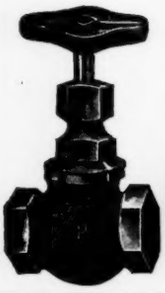

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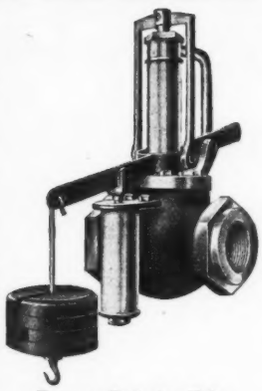

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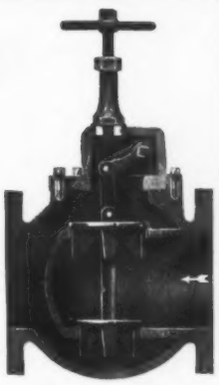

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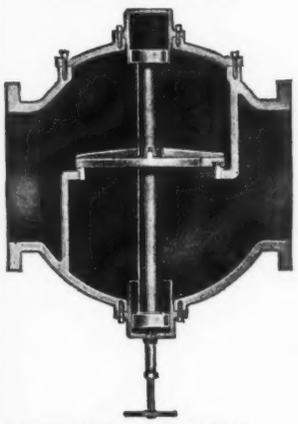

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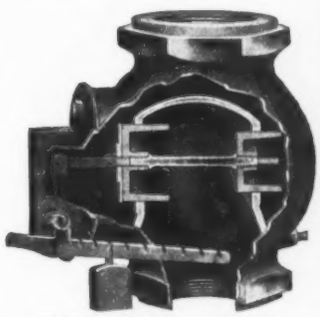

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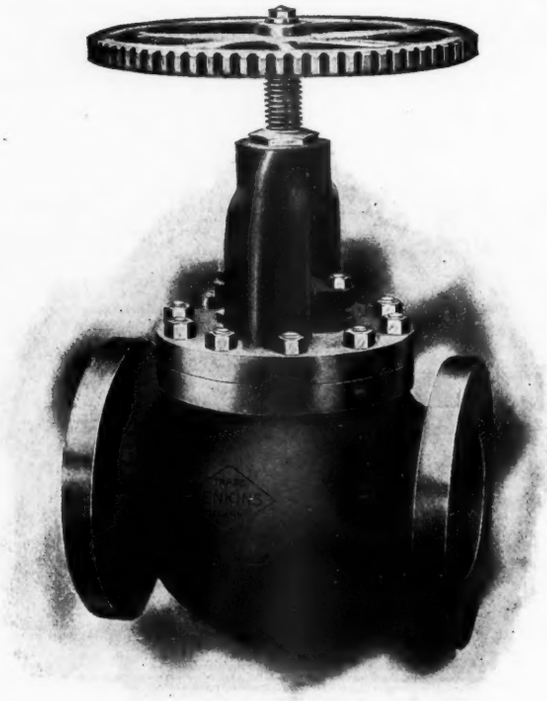

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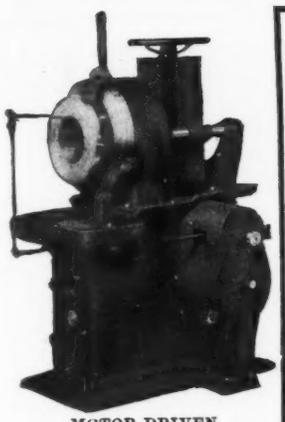

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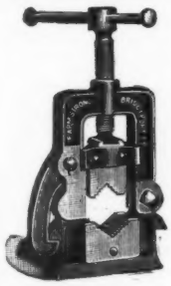

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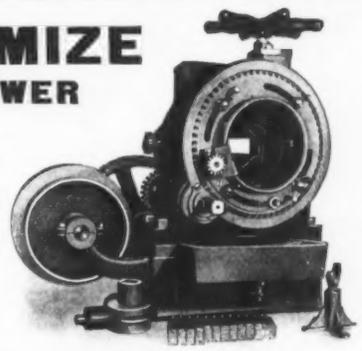

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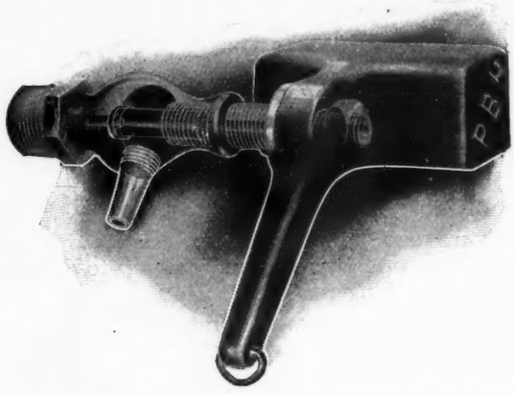

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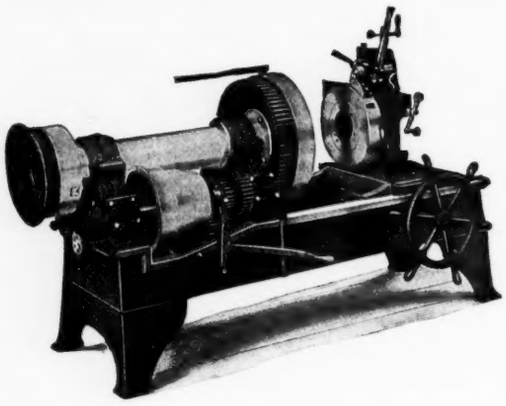

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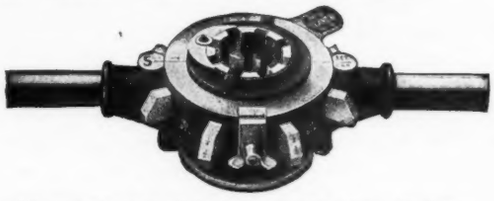


No 6—Cuts ¼ to ¾" without changing dies or bushings.

BEAVER DIE STOCKS ARE MADE IN ALL SIZES. Each size cuts the four sizes within its range without changing dies, adjustable, and capable of cutting nipples and crooked threads.

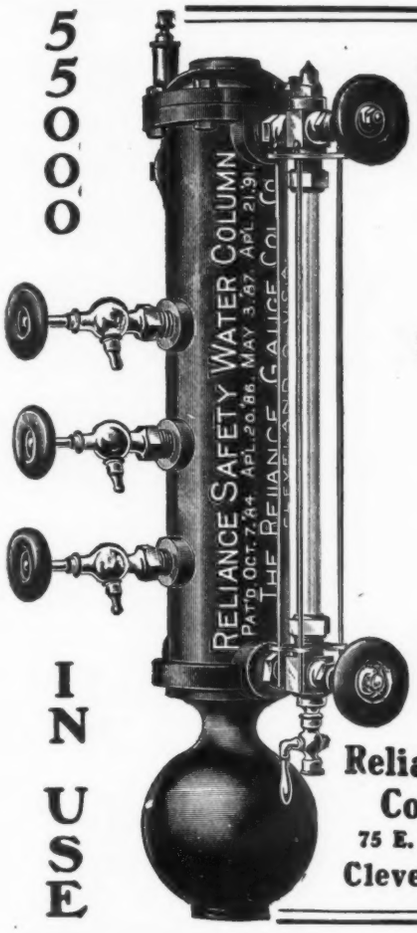
CONSIDER THE CONVENIENCE AND ECONOMY of Die Stocks which save the time of changing dies, no loose parts to get lost or misplaced—and one man can cut ANY size thread.

SOLD ON 10 DAYS' TRIAL BY ALL JOBBERS.

WRITE US TODAY FOR PARTICULARS.

The Borden Co., Warren, Ohio.
DEPT. F.

5000 IN USE



STOP

risking your life on your water level, the

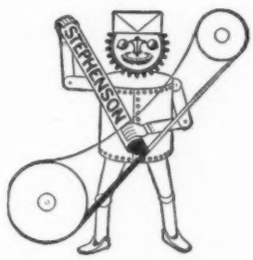
Reliance Safety Water Column

will afford the protection you need, insure dry steam and reduce fuel bills.

Catalog?

The Reliance Gauge Column Co.
75 E. Prospect Street
Cleveland, Ohio

SAMPLES SPEAK LOUDER THAN WORDS



And there is no **string** to this method of selling our

STEPHENSON
Bar Belt Dressing

Send us 2c. for testing Sample, and say which:

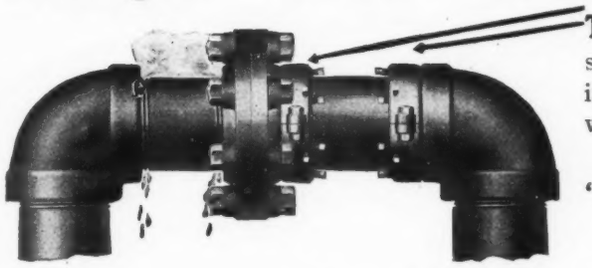
Red Label for Leather belts.
Green Label for Rubber or Canvas.
No **one** kind is good for **all** belts—
you know that.

Of Dealers Everywhere, or

STEPHENSON MFG. CO.
Albany, N. Y.

Agents for England:
J. B. Stone & Co., Finsbury Pavement, London.

Stops The Worst Leaky Joint



The Simplex Pipe Clamp GUARANTEED to absolutely and permanently stop the worst leak. The saving of leakage alone soon pays its cost. Easily applied while pipe is under full pressure.

We'll send one for a 30 days' free trial. If it doesn't "make good," return it at *our expense*. That's fair enough.

Write.

The Simplex Engineering Co.,
316 Preston Street, Philadelphia, Pa.

Robins Laminated Leather Belting

Eliminates The Glue Pot

SOLVES THE BELT PROBLEM.

The Scientific Principle:
Continuous strands are spirally cut from the choicest leather locations of the belting butt to exact mechanical gauge. The strands are then separately stretched to the extreme elastic limit and assembled on edge forming a belt of any practical length, width or thickness. Made endless on pulleys with a simple interlocking splice.

The Positive Result:
A continuous belt without laps, plies or cement. Absolute uniformity of strength, gauge, balance and flexibility. Complete adjustment to varying pulley conditions with the maximum of surface and circumferential contact. Remarkable power transmission and highest productive efficiency.

Write for Circular No. 2 giving detailed description.

ROBINS NEW CONVEYOR COMPANY

NEW YORK, 38 Wall Street. *FACTORY,* 168 Duane Street, N. Y. *CHICAGO,* Old Colony Building.

OXOILOX

will make any belt pliable and tough.

It drives out the old sticky dope that never can do any good, and restores to leather the natural strength and vitality lost in tanning.

OXOILOX is a leather food and preservative, not a drug.

All it does is to keep leather soft and strong and tough, so that it clings closely to the pulleys. But that is the whole theory of correct belt practice. Belts should cling so closely to pulleys that air is excluded from between the two surfaces. The partial vacuum thus formed makes slipping almost impossible and enables belts to do their full duty running slack.

OXOILOX is Nature's remedy for slipping belts.

FREE

F. S. WALTON Co., Philadelphia, Pa.

Gentlemen:—Kindly send me, free of charge, a Sample Can of OXOILOX, the perfect belt dressing.

Name .....

Name of Firm .....

Address .....

Number of belts .....

Average size .....

F. S. WALTON CO., PHILADELPHIA, PA.

PRESSERS AND REFINERS OF ALL GRADES OF NEATSFOOT OIL

WATER PROOF GEM BELT

Not affected by water, steam, oil or gas.
A demonstrated success.
Small samples for test and full information to those interested by inquiring of

JEWELL BELTING COMPANY

Main Office and Belt Factory:
HARTFORD, CONN.

Branches: NEW YORK PHILADELPHIA CHICAGO

SAVE POWER BELTING BEARINGS

If you want belts that can run slack and yet develop the most power in severe service, or in changing temperature and humidity.

If you want belts that will last nearly a life-time without sign of weakness,

SHULTZ SABLE RAWHIDE BELTING

will fulfill your requirements.

Get a SHULTZ SABLE RAWHIDE BELT for 60 days free trial.

SHULTZ BELTING CO., St. Louis, Mo.

NEW YORK BOSTON PHILADELPHIA No. 37 A

SAGINAW MANUFACTURING CO.,
SAGINAW, MICH., U. S. A.
MANUFACTURERS OF
GILBERT WOOD SPLIT PULLEYS.
New York Branch, 88 Warren Street.
Chicago Branch, 32 South Canal Street.
Sales Agencies in all principal cities.
Cable Address, "Engrave" A. B. C. and Lieber's Code.

RHOADS LEATHER BELTING

NOTE OUR PAGE AD. IN FIRST ISSUE OF EACH MONTH

J. E. Rhoads & Sons

PHILADELPHIA 12 N. THIRD ST. BOSTON NEW YORK 40 FULTON ST.

HAMBLET & HAYES CO., EASTERN AGENTS, 105-111 SUMMER ST.

FACTORY WILMINGTON, DEL.

MANGANESITE PASTE

(TRADE MARK REGISTERED)

A Superior NON-POISONOUS Jointing Material of Metallic Composition; for FLANGE and SCREW-JOINTS of every description on Steam, Water, Air, Gas, Ammonia, etc. UNITES TWO METALS AS ONE. Cheaper, more efficient than red lead—no waste in its use.

WALCH & WYETH, 87 Lake St., CHICAGO.

Manufacturers of the Erwood Straightway Swing Gate Valve. Many valuable features in one valve. Write for Catalog.

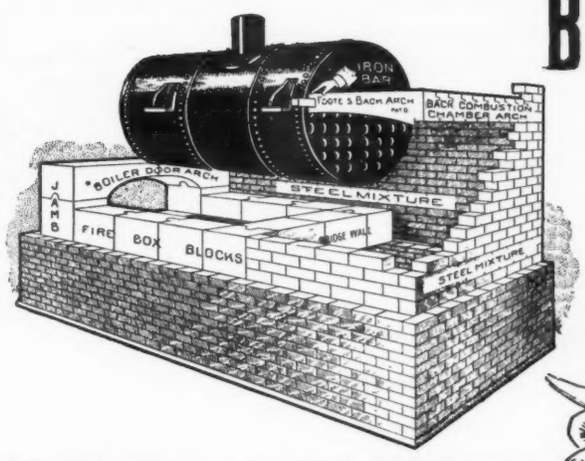
"SIROCCO" TRADE MARK **BLOWERS**

Save Power, Space, Weight

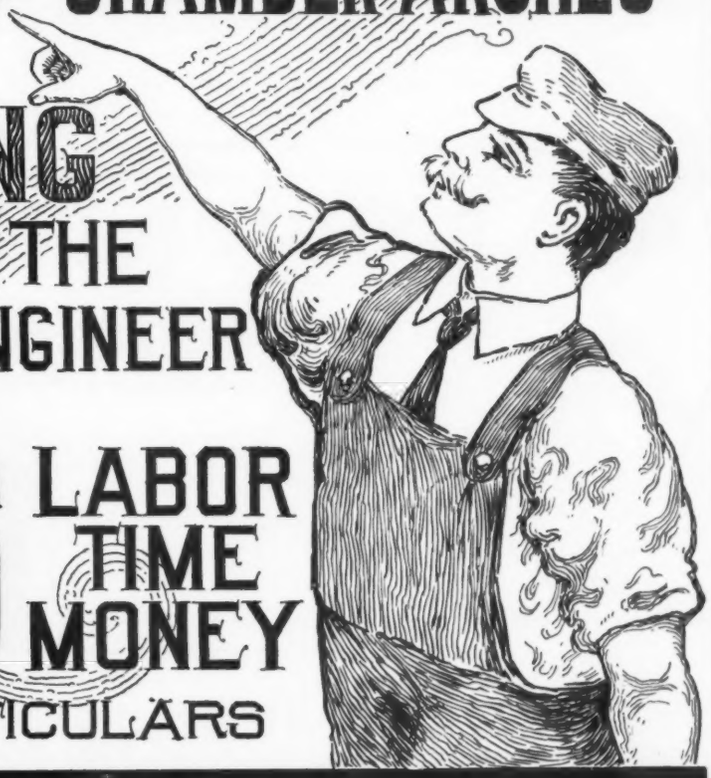
Send for Bulletin describing the original turbine blower.

SIROCCO ENGINEERING CO., 138 Cedar Street, New York.

"STEEL MIXTURE"



BOILER DOOR ARCHES
FIRE BOX BLOCKS
COMBUSTION CHAMBER ARCHES



THE SETTING
THAT SOLVES THE PROBLEMS OF THE ENGINEER AND

SAVES LABOR TIME MONEY

WRITE FOR PARTICULARS

MANUFACTURED BY

McLEOD & HENRY CO.

TROY, N.Y., U.S.A.

BRANCH OFFICE, 1402 BROADWAY, NEW YORK CITY.

The Coal That is Wasted by the Old Stoking Method

would, in a year, pay for a Wilkinson Automatic Stoker and Smoke Preventer which would save 15% of your fuel, decrease stoking costs and cut out many repair bills. *Write.*

THE WILKINSON MFG. COMPANY, Bridgeport, Montgomery Co., Pa.

ANY TYPE OF BOILER

The Murphy Automatic Smokeless Furnace

burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.

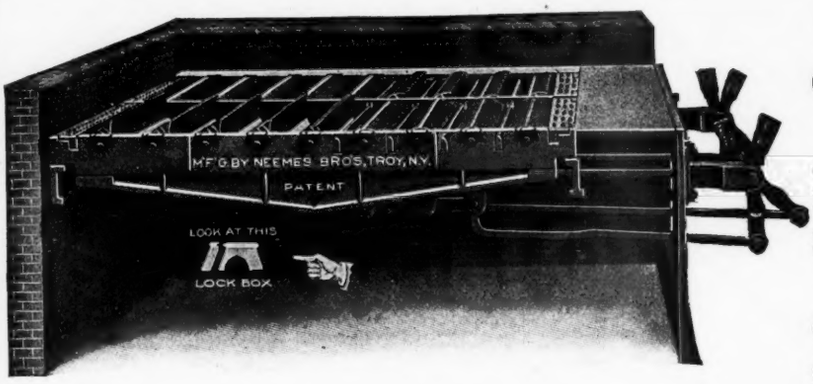
MURPHY IRON WORKS, 5 Walker St., DETROIT, MICH.

UNITS OF ANY SIZE

PREVENT SMOKE

Write to us for descriptive matter relating to a device that is mechanically correct, simple in construction, absolutely automatic, and its effectiveness in preventing smoke from Bituminous coal under any and all conditions has been fully demonstrated.

CLIMAX SMOKE PREVENTER COMPANY
205 Equitable Building, Boston, Mass.



NEEMES BROS.

IMPROVED

Clinker Cutting, Shaking and Dumping Grate

unlike all other grates will cut from both sides of the shaker alike. Makes more steam with cheaper fuel and less of it. A slight agitation shakes out the ashes or a full opening dumps everything into the ashpit. *Write.*

NEEMES BROS.,
41-49 Adams St., TROY, NEW YORK

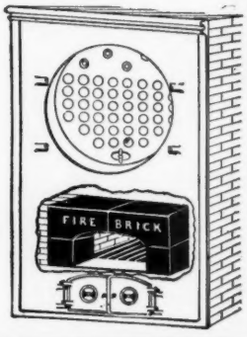
C. W. VAN BLARCOM, Room 533, Terminal Bldg., 30 Church St., Agent for New York City and vicinity BABCOCK & WILCOX, Ltd., Montreal, Canada, Sole makers for Canada BURKE ENGINEERING CO., 311 Industrial Bldg., Providence, R. I., Sole Agents for the New England States.

HEAT PROOF

The heat resistance of our fire brick is wonderful. We fit every type of boiler setting.

Write for catalog and prices.

Presbrey Fire Brick Works, Taunton, Mass.



MARTIN GRATES

Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.

MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.

GREEN TRAVELING CHAIN GRATES

AUTOMATIC SELF CLEANING SMOKELESS

GREEN ENGINEERING CO.
COMMERCIAL NATIONAL BANK BLDG., CHICAGO.
ALLIS-CHALMERS CO. CHICAGO, ILL., EXCLUSIVE AGENTS FOR ALL FOREIGN COUNTRIES EXCEPT CANADA AND MEXICO
GENERAL FOUNDRY WORK A SPECIALTY

These samples from a well-known New England plant show how a

BLACKBURN-SMITH FEED-WATER FILTER AND GREASE EXTRACTOR

turns dirty water or condensed exhaust into good boiler feed.

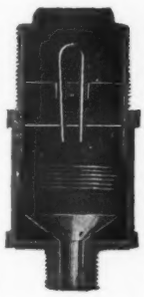
The first sample contains traces of oil, rust, and other dirt from the heating system. The second, which is as clear as crystal, was taken after running the feed through our 2-in. filter at boiler pressure of 100 lbs. and temperature of 225° F.

It pays to save and filter the condensation. You don't have to buy as much water, you keep scale-forming matter out and you reduce repair and coal bills by putting into the boiler pure hot water which would otherwise go to waste. *Write for treatise, "Feed Water Filtration."*

JAMES BEGGS & CO., 106 Liberty St., New York

18

The "Philadelphia" Grease Cup



Automatic application of grease to the bearing without the use of spring compression. : : : :

Nature Supplies the Feeding Force in the Form of Compressed Air. : : : : : :

With many thousands of the "Philadelphia" Grease Cups in successful operation, on machinery of almost every description, we offer a system of lubrication which, for simplicity, cleanliness, economy, reliability and efficiency has no equal.

The "Philadelphia" Cup is not merely "as good as any other:" IT IS THE BEST, and we are prepared to prove our claim for actual superiority. There are more reasons for its practical success than we have room to mention here.

Write for catalogue and full information

The Philadelphia Lubricator & Manufacturing Co.

The Bourse (Exhibition Dept.), Philadelphia, Pa.

COLD WEATHER

Cold Weather Will Not Affect The

LATEST IMPROVED

ROCHESTER

AUTOMATIC LUBRICATOR

Because from the lubricator to the cylinder there is a continuous column of oil with a positive pump at the lubricator end. When the pump works the oil has to move whether it is thick or thin.

Don't put off ordering till your present lubricator fails you.

GREENE, TWEED & CO.

109 Duane Street, New York

There Can be no Failure with a Genuine "DETROIT" Lubricator

Don't Play Second Fiddle

When a little advertising will put you in first place and much will make you leader of the band. Even this small space will keep you in the index and within reach of *Power and The Engineer's* mighty host of live readers.

POWER AND THE ENGINEER, 505 Pearl Street, New York City

Foster Superheaters

Prevent condensation in long steam pipes.

POWER SPECIALTY CO.,
111 BROADWAY, NEW YORK.

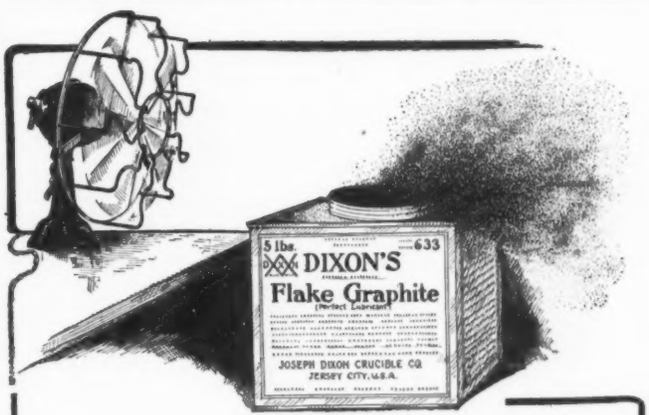
Over 7500 Hammel Oil Burners

In use under Stationary Boilers, Locomotives, Kilns, Etc.

Write for Circular of Hammel Patent Furnace for Water-Tube Boilers

HAMMEL OIL BURNER CO.

609 North Main Street, LOS ANGELES, CAL.



Keeps Bearings Cool.

If you have some bearing that gives you more or less trouble, or are experiencing any difficulties in lubricating anything, you should try

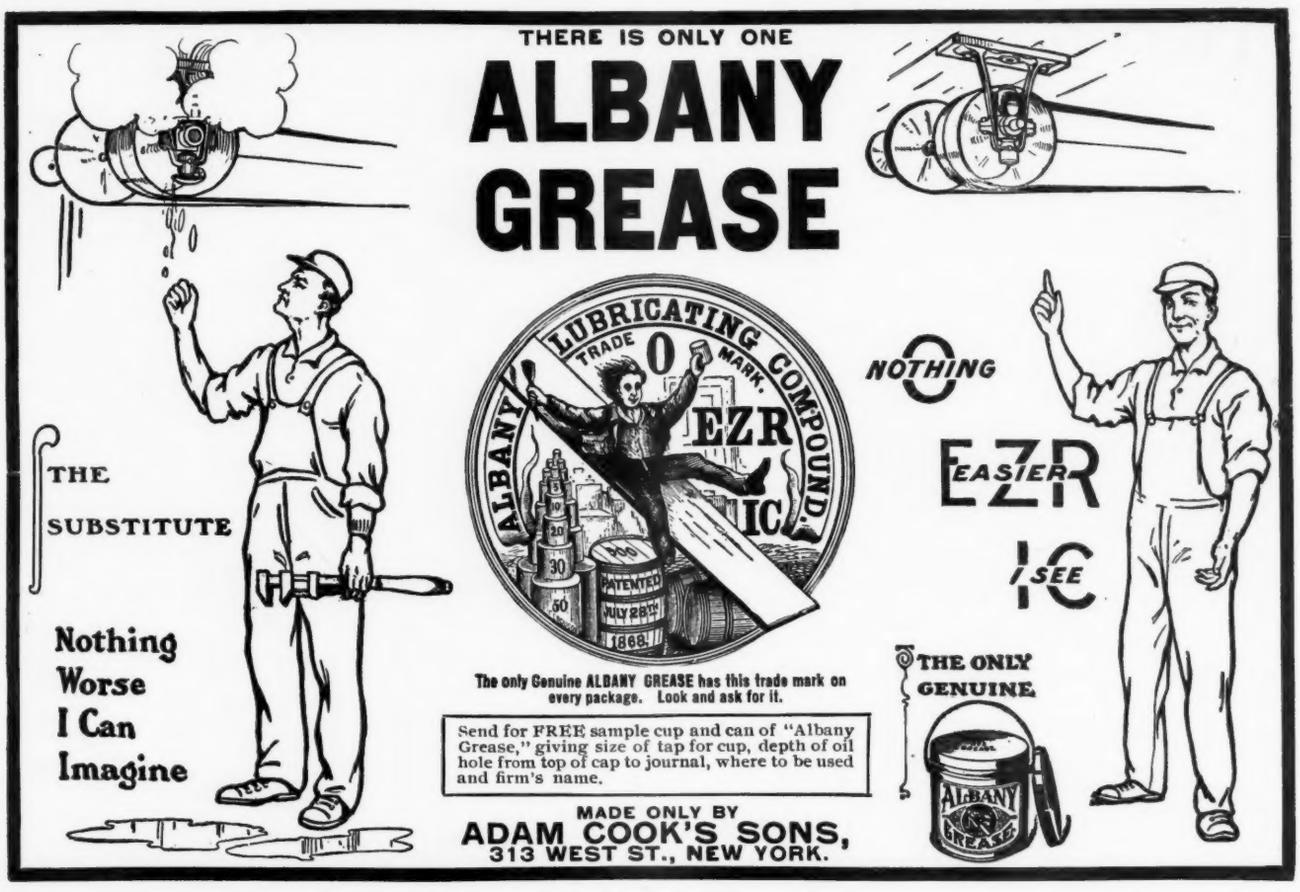
Dixon's Flake Graphite.

While this remedy is almost infallible, it is the best practise to use a little of Dixon's Flake Graphite regularly and then friction troubles will never get a start.

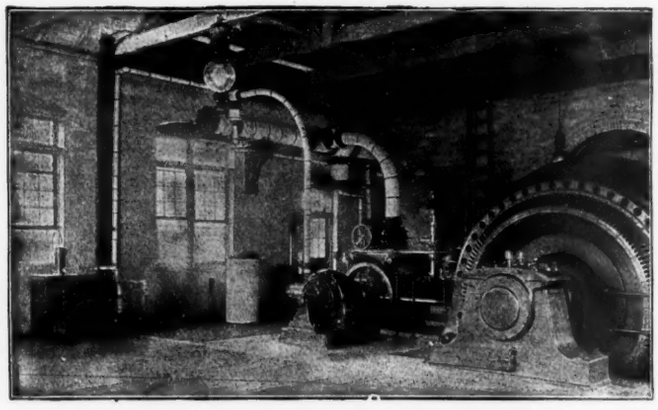
Write for free sample 94-C

JOSEPH DIXON CRUCIBLE CO.

JERSEY CITY, N. J.


THERE IS ONLY ONE
ALBANY GREASE
THE SUBSTITUTE
Nothing Worse I Can Imagine
LUBRICATING COMPOUND
TRADE MARK
ALBANY
EZR
IC
PATENTED JULY 28TH 1868
NOTHING
EASIER
EZR
I SEE
IC
The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.
Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.
THE ONLY GENUINE
ALBANY GREASE
MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.

Engine Oiling In The Modern Power Plant



Down in what most people regard as the wildest part of south central West Virginia, in the territory from which some of our finest smokeless fuels are secured, is the McKell Coal & Coke Co., Glen Jean, W. Va., operating collieries scattered at convenient points over a tract of several thousand acres. Electric power for operating these numerous scattered mines is supplied by an alternating current system of distribution from a central power plant. High-tension alternating current is transmitted from the central station to scattered substations, where it is transformed and converted into low-tension continuous current for use at the adjacent mines.

The illustration shows the first 500-k.w. alternating current generating unit in the power house, which provides space for installation of a duplicate unit. At the left may be seen the Duplex Type White Star Oil Filter and circulating pump of the White Star Continuous Oiling System here in use for lubricating all the engine bearings. Overhead, out of sight among the roof trusses, is a reservoir from which the oil is piped to feeds fitted to all the bearings on the engine. All oily drips from the various bearings are drained to a tank beneath the engine room floor, from which they are lifted automatically to the White Star filter on the engine room floor. After being thoroughly cleaned in the filter, the oil is pumped back to the overhead reservoir, ready for use again. Thus there is a constant stream of oil fed to all bearings, amounting in this case to a circulation of about 200 gallons per day. The reservoir is so arranged that any excess pumped to it would be returned through automatic valves to the filter.

By use of the White Star continuous oiling system the bearings are all supplied with a copious flood of oil, affording that generous supply which is known to be necessary to perfect lubrication, yet *absolutely without waste*, since not a drop of oil can escape from the system, except as it is actually worn out in the bearings.

We are prepared to equip power plants of any size contracting to furnish the necessary apparatus or erecting such outfits complete. Our catalog "D" treats fully on this subject. Send for it.

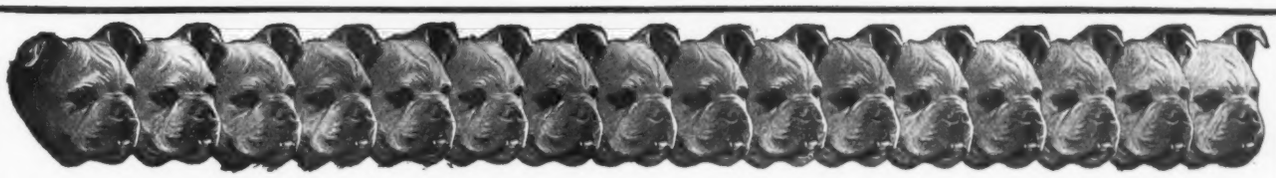
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

"TRIMO"

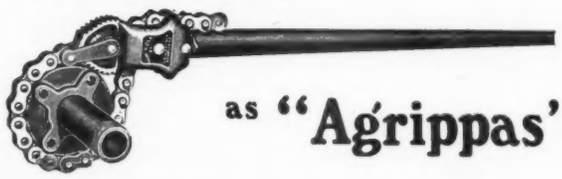
(TRADE MARK)

We want every user of Pipe Wrenches to give the "TRIMO" a trial. We know they will be so well satisfied that they will then use no other. Superior in strength, working qualities, and ability to stand up under hard service. Guaranteed. Send for our Catalog No. 21.

TRIMONT MANUFACTURING COMPANY, 55-71 Amory Street, Roxbury, Mass.



As insistent



as "Agrippas"

as we may seem on question of Chain Pipe Wrenches, we believe the course O. K. Every job has its kinks and irregular, close or cramped fittings, too cramped for other tools with two jaws. Agrippas have one jaw, all the strength and "get there" on any kind of work. Agrippas are practically two tools in one because of utility. Discount and free trial from your dealer.

J. H. WILLIAMS & CO., SUPERIOR DROP FORGINGS,
BROOKLYN AND CHICAGO.

How do you do your Hoisting

In Yale & Towne Chain Blocks

are embodied the final development in lifting mechanism and the highest integrity in Chain Block construction. They lead in efficiency, speed, durability, reliability and universal adaptation to every hoisting requirement.

Triplex Blocks—⅛ to 40 tons. Universally recognized as the most durable and efficient Chain Block made. Have balanced train of spur Gearing with large internal gear.

Duplex Blocks—½ to 10 tons. The handiest and safest Screw Blocks made. Have safety guides to prevent slipping of load chains. Bronze Worm wheels and steel worms with hardened and ground thrust bearings running in oil.

Differential Blocks—⅛ to 3 tons Not as durable or easy lifting as the Triplex or Duplex, but safe and twice as durable as the cheaper kind of the Weston Differential Block, because of superior Chain and Sheaves.

Y. & T. Blocks, duplicate parts and trolleys are carried in stock by Hardware, Machinery and Mill Supply Dealers. Write for catalog.

The Yale & Towne Mfg. Co.,
9 Murray Street, New York.

The "Swartwout"

Gravity-Closing
Weather-Proof
Non-Binding
Non-Rattling
Easily Operated

VENTILATORS

The weight of the adjustable cone keeps the ventilator closed, unless intentionally open by a pull of the chain. The degree of ventilation is exactly regulated.

THE OHIO BLOWER CO.
SOLE MANUFACTURERS
CLEVELAND, OHIO.

1-43

OF WHAT USE ARE BAFFLE PLATES

in a separator anyway?

They don't arrest the water when it comes in a rush except to break it into fine particles that are the more easily carried off with the steam

Therefore the

STRATTON SEPARATOR

has none of them.

It throws the water out of the steam by centrifugal force and lets only the pure dry article pass to the engine.

The STRATTON always does the work when others fail.

Goubert Manufacturing Co.,
No. 90 West Street,
NEW YORK CITY, N. Y.

Plenty of Room for the steam to pass—Plenty of surface to catch condensation in The Gardner Horizontal Separator.

CATALOG

The Gardner Governor & Separator Co.,
Quincy, Illinois.

BAUM SEPARATORS

ARE BEST for Live and Exhaust Steam.

Positively Guaranteed.

"I take pleasure in stating that this department has used the Baum Separators for a considerable time, and has found them to be all you claim for them and are satisfactory in every respect." —The Superintendent of Public Buildings, Albany, N. Y.

Send for new Catalogue and prices.

Hershey Machine & Foundry Co.

85 Water Street, Boston, Mass.
MANHEIM PA., U. S. A.

W. G. Ruggles Co, 54 High St., Boston, Mass.
R. D. Bliss, 40 Dearborn St., Chicago, Ill.

Carey's 85 per cent Carbonate Magnesia Coverings

THE largest contract ever awarded for steam pipe and boiler coverings specified Carey's. This was the result of an exhaustive test conducted by the Manhattan Railway Company of New York, which proved Carey's Coverings to be more efficient and far superior in every way to any other of the numerous makes. No other coverings proved to be as light, clean and substantial.

Carey's Coverings are absolutely fire-proof, and being thorough non-conductors of heat they confine the heat to the pipes, effectually preventing its loss through radiation, thus saving in fuel an amount sufficient to *more* than offset the cost of their application.

The most prominent steam users everywhere use Carey's Covering. Do you want to know why?

Send for Carey's Magnesia Catalogue. It gives information not obtainable elsewhere.

THE PHILIP CAREY COMPANY

General Offices: Station R, Cincinnati, O.

FACTORIES: Lockland, Ohio; Plymouth Meeting, Pa.

Branches and Warerooms:

New York: 114-118 Liberty Street.
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Philadelphia, Pa.: 12th and Buttonwood Sts.
Toronto, Canada: 112 Bay Street, East.
Cleveland, Ohio: 123 Water Street.
Buffalo, N. Y.: 45 Pearl Street.
Pittsburg, Pa.: 333-335 Second Avenue.
Atlanta, Ga.: 34 West Alabama Street.
Charlotte, N. C.: East 7th and R. R. Streets.
New Orleans, La.: 222 Chartres Street.

Yes, We Do

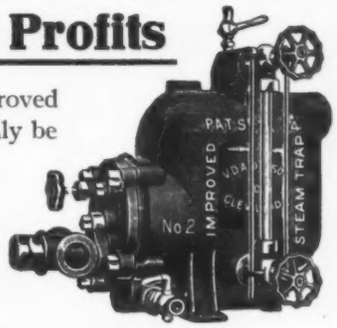
send out GEIPEL STEAM TRAPS on approval. Shall we send you one?

Circulars on request.

JOHN PLATT & COMPANY,
99 Cedar St., New York.

A Trap for Profits

The Anderson Improved Steam Trap can easily be turned inside out if it ever becomes necessary to get at the working parts. *Ask about it.*



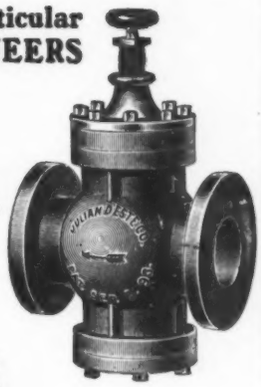
THE V. D. ANDERSON CO.,
1935 West 96th Street CLEVELAND, OHIO.

Send for Catalog.

Return Steam Trap.

CURTIS SPECIALTIES For particular ENGINEERS

Improved Pressure Regulator
Improved Pump Regulator
Water Pressure Regulator
Expansion Trap
Balanced Steam Trap
Return Steam Trap
Relief Valve for Steam and Water
Separator
Cellar Drainer
Temperature Regulator
Tank Governor and Pump
Damper Regulator
U. S. Ball Cock



JULIAN D'ESTE CO., 24 Canal Street, BOSTON, MASS.

You Can See It Work

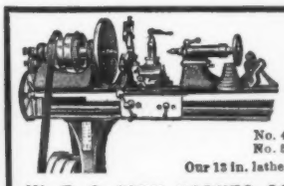
The MOREHEAD NON-RETURN STEAM TRAP contains no troublesome valves, floats or buckets inside. All working parts are placed outside, and you can *see it work*. When ready to discharge, the force of gravity causes the trap to tilt. It is absolutely reliable. Write for descriptive catalog.

MOREHEAD MANUFACTURING CO., 1051 Grand River Ave., Detroit, Mich.

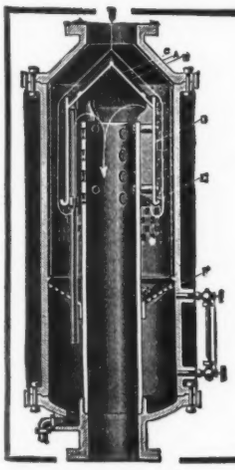
ELEPHANT BRAND

DELTA
REG. U. S. PAT. OFF.

THE PHOSPHOR BRONZE SMELTING CO., Limited.
2200 WASHINGTON AVENUE, PHILADELPHIA, PA.
ELEPHANT BRAND "Phosphor Bronze"
INGOTS, CASTINGS, WIRE, RODS, SHEETS, Etc.
— DELTA METAL —
CASTINGS, STAMPINGS AND FORGINGS
ORIGINAL AND SOLE MAKERS IN THE U. S.



"The BARNES"
LATHES
W.F. AND J.C.
9 in. to 13 in. Swing.
No. 4½ Lathe, 9 in. x 25 in., List $ 75.00
No. 5 Lathe, 11 in. x 34 in., List 100.00
Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.
W. F. & JOHN BARNES CO., 990 Ruby Street, Rockford, Ill.



DON'T

buy a steam or oil separator without sending for catalog describing

SWEET'S

and then *read* and *think* about it and you'll order one: 6000 in use; deliver steam 99.8 dry; takes out all the oil, that is 99%.

DIRECT SEPARATOR COMPANY
712 South Geddes Street SYRACUSE, N. Y.

A Fat Pay Envelope

goes to the man who knows, and this recording meter furnishes the requisite information. A continuous, permanent record, which may be read at any minute or be filed away for future reference.

WRITE.

G. C. ST. JOHN,
140 Cedar St., New York.

The St. John Indicating and Recording Steam Meter

4/S

Steam Traps

GET

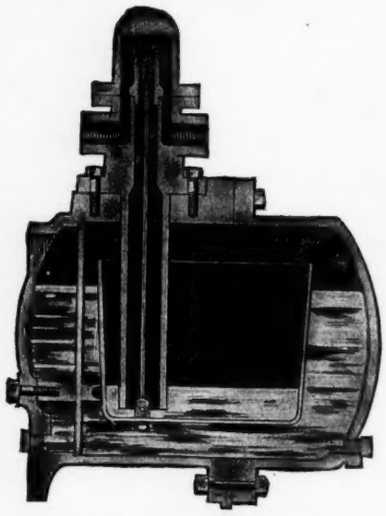
Our Catalog "A"

read what we have to say about steam traps.

See where the valve is?

Is not that a good idea?

Shall we send "A"?



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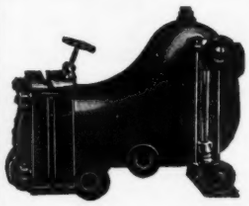
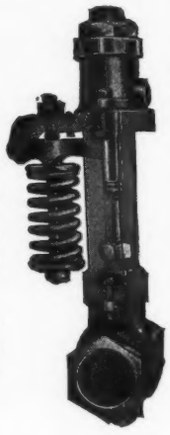


McDANIEL STEAM TRAPS

are especially adapted for draining steam separators and high pressure mains. Also good for steam heating. All working parts are attached to the bonnet, and are removable with it. Valve outlets are large, to give rapid discharges of condensation.

Watson Steam Pump Governor



should be used on all steam pumps where a fixed discharge pressure is desired.

The construction permits of easy access to the stuffing box for removing packing, and the spring can be adjusted or entirely removed without interfering with any other part of the valve. Any practical man will readily see its advantages.

All our goods are made in our own factory and tested before shipping. We guarantee them to give perfect satisfaction. Established 1878.

Send for Catalogue.

Watson & McDaniel Co.,

148 North 7th Street, Philadelphia, Pa.

Nason Manufacturing Company's

STEAM TRAPS

SPECIFY:

Class B for pressures less than 20 lbs.

Class C for pressures 20 to 70 lbs.

"Sidelus" for pressures 40 to 150 lbs.

THE TRAP THAT ALWAYS "FILLS THE BILL"

Nason Manufacturing Company's

"Immersed Valve" Boiler Feeder

FOR LOW PRESSURE STEAM BOILERS

As a safeguard against the destruction of boilers through careless handling they are a necessary adjunct. Special Catalog.

NASON MANUFACTURING COMPANY

71 FULTON STREET, NEW YORK

Halve the Trouble

AND

DOUBLE THE PROFIT

Kitts Specialties

Steam Traps	Pump Governors
Reducing Valves	Fan Engine Regulators
Safety Water Columns	Damper Regulators
Low Water Alarms	Safety Feed Water
Low Pressure Boiler Feeders	Regulators
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Write For Catalog

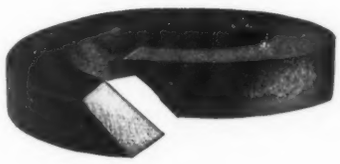
Kitts Manufacturing Co.

OSWEGO, N. Y.

PEERLESS PISTON AND VALVE ROD PACKING

We make the Peerless Piston and Valve Rod Packing round and square. It is put up in coil, spiral and ring form.

Will hold FOUR HUNDRED POUNDS of Steam


Style 1

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In sizes from One-eighth Inch to Two and One-Half Inches

YOU CAN GET FROM 12 TO 18 MONTHS' PERFECT SERVICE FROM PEERLESS PACKING

For high or low pressure steam the Peerless is HEAD and SHOULDERS above all other packings.

Manufactured Exclusively by

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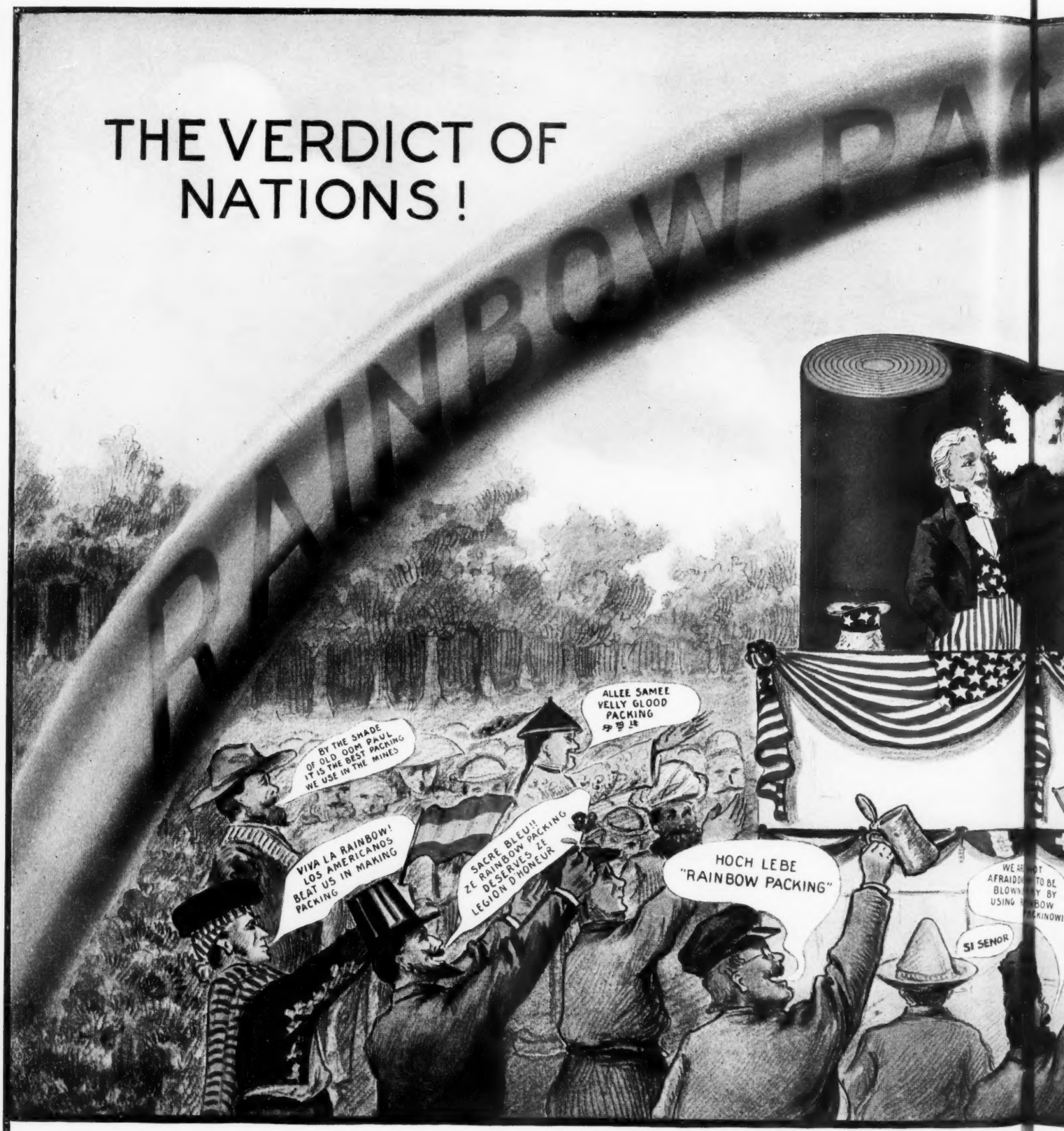

THE VERDICT OF NATIONS!
RAINBOW
BY THE SHADE OF OLD OOM PAUL IT IS THE BEST PACKING WE USE IN THE MINES
ALLEE SAMEE VELLY GLOOD PACKING
VIVA LA RAINBOW! LOS AMERICANOS BEAT US IN MAKING PACKING
SACRE BLEU!! ZE RAINBOW PACKING DESERVES ZE LEGION D'HONEUR
HOCH LEBE "RAINBOW PACKING"
SI SENOR

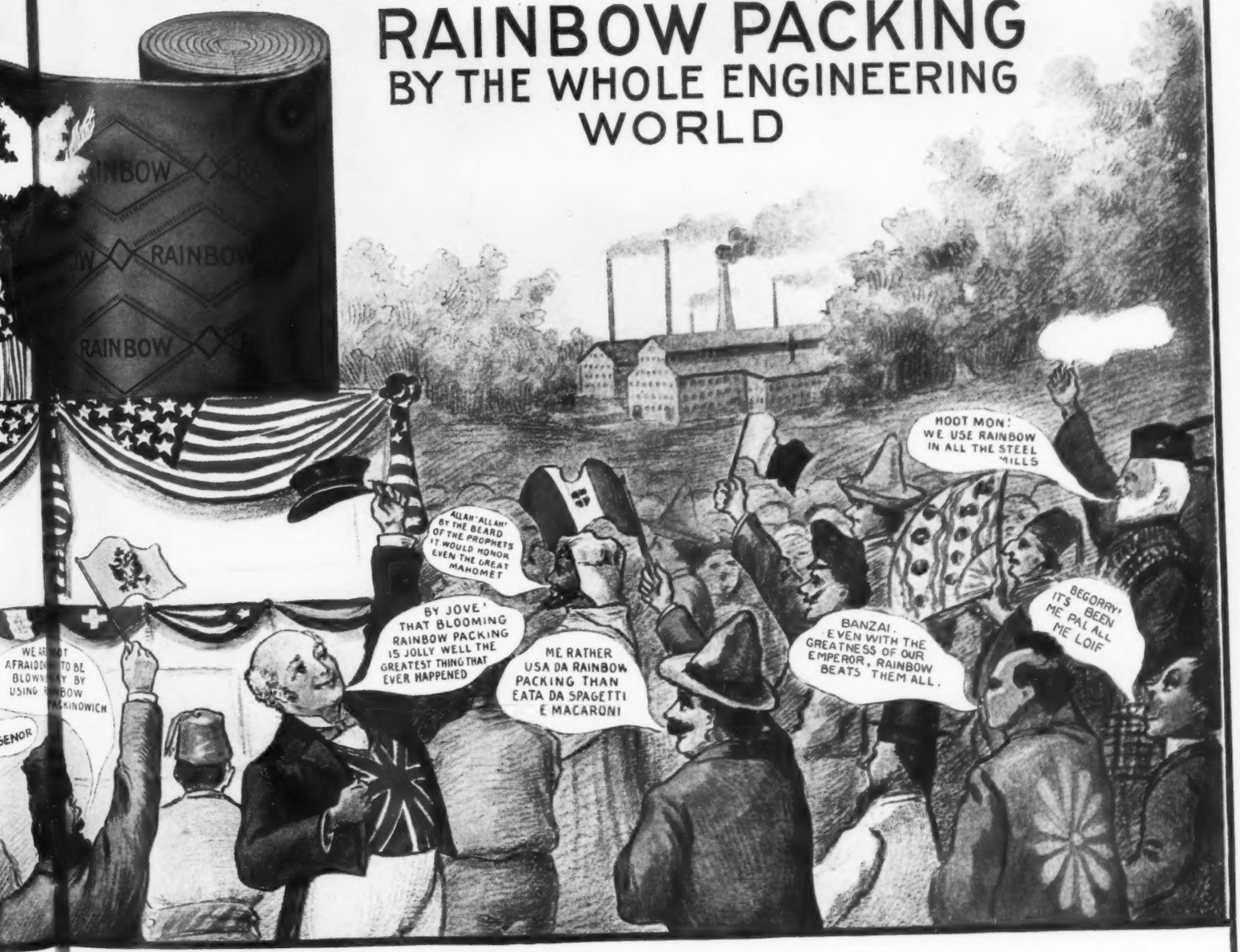
MANUFACTURED

THE PEERLESS RUBBER

16 WARREN ST. AN

NEW Y

THE HIGHEST TRIBUTE HAS BEEN PAID TO THE INCOMPARABLE QUALITIES OF RAINBOW PACKING BY THE WHOLE ENGINEERING WORLD

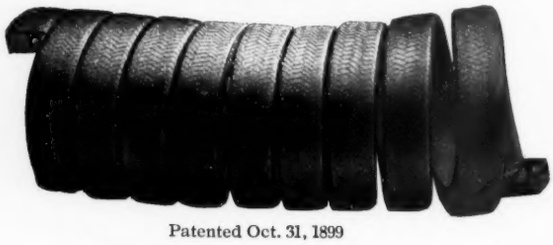

RAINBOW
RAINBOW
RAINBOW
ALLAH! ALLAH! BY THE BEARD OF THE PROPHETS IT WOULD HONOR EVEN THE GREAT MAHOMET
BY JOVE! THAT BLOOMING RAINBOW PACKING IS JOLLY WELL THE GREATEST THING THAT EVER HAPPENED
ME RATHER USA DA RAINBOW PACKING THAN EATA DA SPAGETTI E MACARONI
BANZAI. EVEN WITH THE GREATNESS OF OUR EMPEROR, RAINBOW BEATS THEM ALL.
HOOT MON! WE USE RAINBOW IN ALL THE STEEL MILLS
BEGORRY! IT'S BEEN ME PAL ALL ME LOIF

SOLELY BY
MANUFACTURING CO.
88 CHAMBERS ST.
NEW YORK

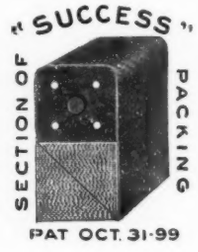
THE ECLIPSE SECTIONAL RAINBOW GASKET

The original and only genuine Sectional Gasket—manufactured from the celebrated Rainbow Packing Compound. Beware of cheap tubings and worthless imitations. Be sure the name Eclipse is embedded in the gasket at intervals of six inches.

SUCCESS SEMI-METALLIC DIAGONAL EXPANSION SPIRAL PACKING RAINBOW CORE



Patented Oct. 31, 1899



The "Success" is the "Best" Combination Packing yet devised, both as regards principle of Construction and Material used, for Steam (low or high pressure), for Water (hot or cold), and for Ammonia Machines. The Spiral form is the correct shape of all Modern Constructed Packing, and readily and quickly conforms to the ring shape so greatly desired. The Soft Metal used is a Wear Resister; it is an Automatic Expander under heat conditions; it will not scratch or cut the rod under any conditions.

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Why Take Chances When Buying Gaskets?

You know what it means to you every time a gasket goes wrong. Then why use gaskets that you cannot depend on? You can easily satisfy yourself as to which gaskets can be depended on if you consider their construction and the materials of which they are made.

You know, for instance, that rubber and organic materials will burn, char and harden under heat. And you know that Asbestos—which is a mineral—cannot be injured by heat or chemicals. Doesn't it stand to reason, therefore, that gaskets made of asbestos will stand the extreme heat, to which they are subjected in modern steam engineering, better than rubber or organic gaskets?

KEARSARGE JOINTLESS GASKETS are made of PURE ASBESTOS. They will not show any deterioration even if held in front of a blow torch.

You know that gaskets made of flimsy materials will almost invariably blow out.

Kearsage Jointless Gaskets

have fine brass wires twisted in each strand of the asbestos cloth, which gives them exceptional strength. They will stand a steam pressure of 250 lbs.

If gaskets have a taped joint, it is plain that they cannot be as strong as gaskets made all in one piece. KEARSARGE JOINTLESS GASKETS are made of one endless piece of asbestos cloth. They have no joints to pull apart or blow out.

Now don't think that because KEARSARGE JOINTLESS GASKETS are so much better than others that they are high priced, for they are the cheapest in first cost and the cheapest in the end. Being 25 per cent. lighter in weight than ordinary asbestos gaskets, you get more per pound, and one KEARSARGE will last as long as six ordinary gaskets.

Do you wonder that KEARSARGE JOINTLESS GASKETS have stood the test of over half a century?

Write today for Kearsarge Booklet and Further Particulars.

H. W. Johns-Manville Co.

Manufacturers of Asbestos and Magnesia Products, Asbestos Roofings, Packings, Electrical Supplies, Etc.

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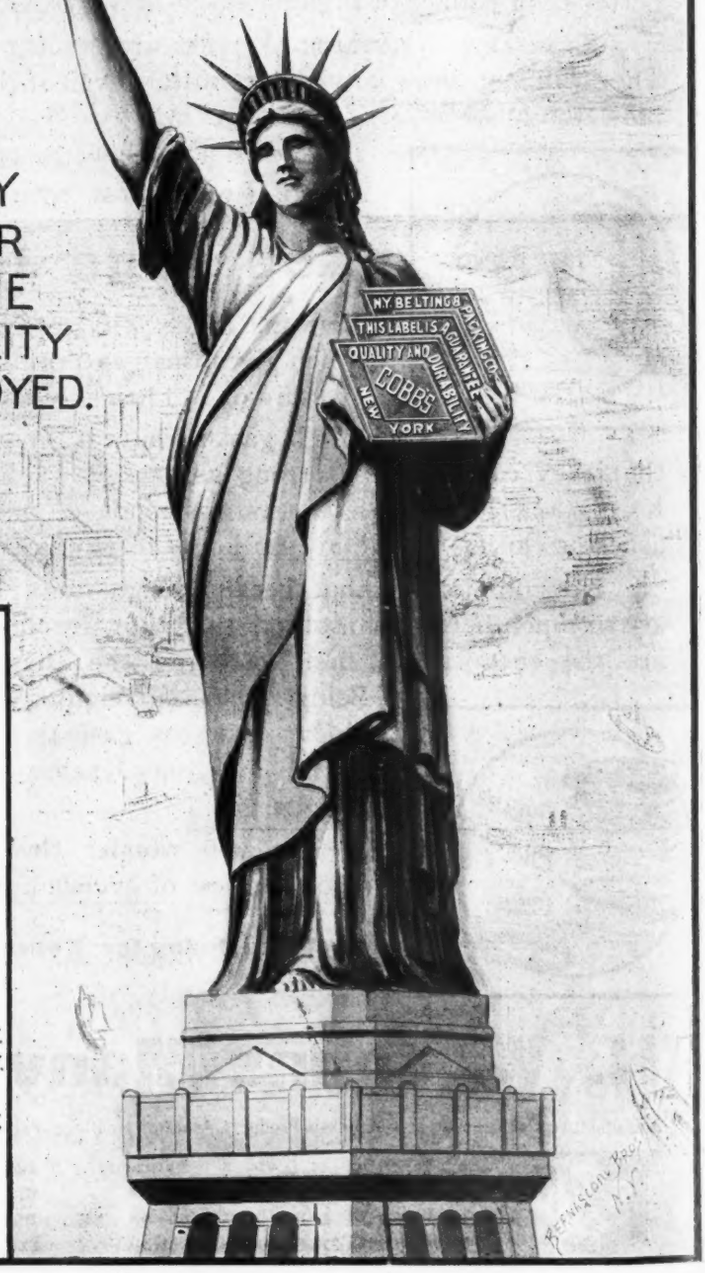
844

COBB'S PISTON AND VALVE ROD PACKING

IS AN ENLIGHTENMENT TO THE ENGINEERING WORLD

BY USING
COBB'S PACKING,
ENGINEERS ENJOY
FREEDOM FROM WORRY
OWING TO THE SUPERIOR
CONSTRUCTION OF SAME
AND THE EXCELLENT QUALITY
OF THE MATERIALS EMPLOYED.



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NEW YORK BELTING AND PACKING CO LTD.
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BELMONT
"1903"
EXPANSION PACKING

For Steam and Ammonia

Pat. Feb. 24, 1903.

See the sliding wedge ?

When you place a ring in the stuffing box pull the ends of one wedge ahead of the casing ends, and push the other one back, then when the ring is closed and ready for service the joint is divided into three breaks, occurring at different points on the circumference. This feature enables one ring of **Belmont 1903 Expansion Packing** to stop steam as effectively as three rings of ordinary packing, and makes it especially valuable for shallow stuffing boxes. Material throughout is the best obtainable, and **Belmont 1903 Expansion Packing** (fully described in booklet A) is guaranteed for any service with steam or ammonia up to 125 lbs. pressure. Above this pressure our "high pressure" packing (write for booklet B) is to be preferred. *General Catalog on Request.*

FREE !

Send for a sample ring and be convinced.

CLEMENT RESTEIN CO.,
Philadelphia, Pa.

Gentlemen :—
Send me a sample ring of Belmont 1903 Expansion Packing

Name.....
Address.....
Firm Name.....
Number of Engines.....
Number of Pumps.....
Number of Boilers.....
High or Low Pressure.....
Packing now in use.....

Power, 7-7 08.

CLEMENT RESTEIN COMPANY

133 North Second St. PHILADELPHIA, PA.

There are Other Eureka Packings

Besides the well-known GUM CORE we are also manufacturing large quantities of Eureka Cut Ring, High Pressure, Water Proof and Red Sheet.

ASK YOUR DEALER FOR GENUINE EUREKA

THIS LABEL ON PACKING "EUREKA" TRADE MARK. IS A GUARANTEE OF EXCELLENCE.

Cut Rings
and in Spiral Form

is the same in quality as our famous Eureka Gum Core. Guaranteed equal to any ring packing on the market.

High Pressure
in Coils and Rings

Finest material, treated by our process, makes this packing practically indestructible.

Water Proof
in Coils and Rings

Made of pure long line flax specially treated to make it most efficient for all hydraulic uses.

Red Sheet

Sold under an absolute quality guarantee. None better can be made.

Our Prices and Delivery will interest you. Write for them.

Eureka Packing Co.

Jas. L. Robertson, Pres.

46 Warren Street, New York

Even Uneven Surfaces

can be packed securely with

Goetze's Elastic Copper Gaskets

A pipe joint packing for High Pressure Steam, Air Pressure and Superheat.

We'll send you the necessary sample—FREE.

AMERICAN GOETZE GASKET & PACKING COMPANY,
525 East 149th Street, New York, N. Y.

If Uncle Sam *should* have to fight
The tricky little Jap,
He'll surely wipe those Islanders
Completely off the map.
He's got the ships, the cash, the men,
He's got *Black Squadron* too;
So, over there, they'd best beware,
The old *Red, White,* and *Blue.*

BLACK SQUADRON

(THE ORIGINAL SLIDING WEDGE PACKING)

Gives greatest rod pressure, with least friction. Cannot carbonize and score the rod. Remains pliable under all conditions. Will not "melt away" in the stuffing box. Outwears all others.

Booklet on Request.

CANCOS MANUFACTURING CO.,
Philadelphia, Pa.

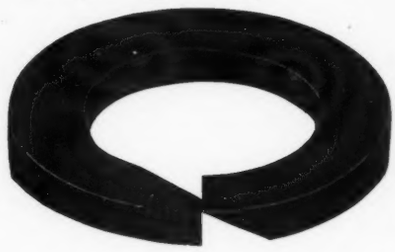
10 Oliver St., Boston, Mass. 525 Third Ave., Pittsburg, Pa. 805 Plowman St., Baltimore, Md.

JOHNSON'S PACKINGS

are made by packing experts, from the very finest materials known for the purpose. No secret process is employed—the right material is put together in the right way and it must work right.

Honesty Makes The Best Quality

If you have any joints that are hard to keep tight, give Johnson Packings a trial. They can be relied upon to give perfect service longer than any others on the market. *Ask for our valuable Catalog.*



THE HENRY JOHNSON COMPANY

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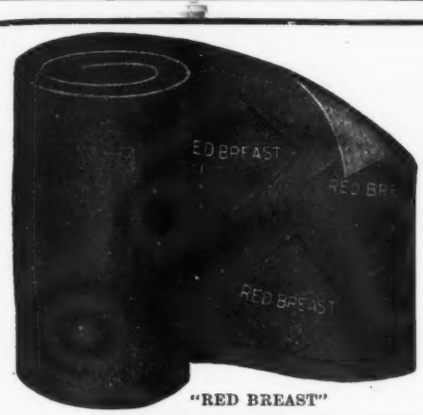


"RED BREAST"

Red Breast Packing

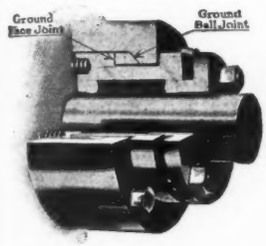
A Standard Red Sheet Packing—Will not crack or harden under any degree of heat; absolutely impervious to the influence of alkalies, oils and ammonia; positively won't contract or expand; and will withstand the highest pressure.

Write for Free Sample

This packing is better than others—far better—and, better still, is lower priced. We will gladly send samples **Free** upon request.

MERCER RUBBER CO., Hamilton Square, New Jersey
BRANCH OFFICES—Philadelphia, New York, Pittsburg, Denver, 610 Exchange Bldg., and Chicago, 40 Dearborn St.

VIBRATING STUFFING BOX



"It Floats with the Rod"

"SAFETY"

PLASTIC

Metallic Packing

FOR STEAM, WATER, AIR, GAS, HYDRAULIC MACHINES, VALVES, ETC.

Guaranteed to stand Steam Temperature up to 550 degrees F. and Hydraulic Pressure to 5,000 lbs. per square inch.

HIGHEST AWARD WORLD'S FAIR, ST. LOUIS.

Send for Free Sample and Particulars

Manufactured Solely by STEEL MILL PACKING COMPANY, Detroit, Mich., U. S. A.

A STEAM PACKING THAT IS A STEAM PACKING

TRADE MARK. REG. IN U. S. PAT. OFF.

All Goods Stamped with the VANDA TRADE-MARK will fulfill the claims we make for them.

VANDA SHEET PACKING

THIS PACKING IS THE PIONEER OF ALL COMPOSITION PACKINGS, AND IMITATORS ARE APPEARING IN GREAT NUMBERS. WE THEREFORE, WOULD ESPECIALLY CALL YOUR ATTENTION TO OUR

TRADE-MARK DEVICE STAMPED ON EVERY SHEET

GOODS MADE IN SHEETS ONLY OF 4½' x 4½' AND 4½' x 9', IN ALL THICKNESSES

THE VANDA COMPANY, 96 SPRING STREET, N. Y.

H. W. JOHNS-MANVILLE CO., CO-DISTRIBUTORS

Send For Free Samples
of Selden and Zena packings. We guarantee satisfaction under the most severe conditions of service. *Write.*
RANDOLPH BRANDT,
72 Cortlandt St., New York.

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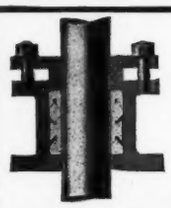
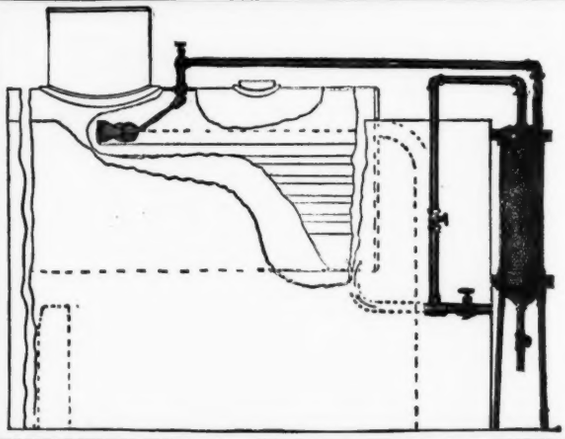


LAW
IMPROVED METALLIC PACKING
adapted for high and low pressures with saturated and superheated steam—air, gas, water, oil, ammonia, etc
HOUCHIN-AIKEN CO., Sole Mfrs.,
37-47 Fifty-third St., Brooklyn, N. Y.

MABBS RAWHIDE PACKING
TRADE

MARK.
The Packing for Water Works, Stern Pipes of Propellors; Deep Mine Pumps, Air Drills, Ice Machines and all machinery using cold water.
Mabbs Hydraulic Packing Co.,
Box 829. CHICAGO.



SKIM THE SCUM

from the water in your boiler as it rises. It is full of sediment, mud and scale forming impurities which the **Buckeye Automatic Boiler Skimmer** will remove to a precipitator outside the boiler. The water will be returned clean and pure before it has a chance to cool. Thus you can prevent scale from forming at *no expense* save *first cost.* We'll send a "Buckeye" for a 30 days' free trial. You *can't lose.*

BUCKEYE BOILER SKIMMER COMPANY,
SOUTH END, TOLEDO, OHIO.

DON'T LET SCALE FILL YOUR BOILERS

It's better to precipitate and blow off scale forming matter than to let it blow up the boiler.

BIRD-ARCHER BOILER COMPOUNDS

absolutely prevent every trouble caused by scale, prevent pitting and corrosion, and do it without injury to the boiler or fittings. The BIRD-ARCHER method involves no costly labor, no shut-downs, no hard work, and means fewer leaky tube ends and less coal.

Try BIRD-ARCHER Compound at our expense.

ASK FOR OUR FREE BOOK
"TEN QUESTIONS FOR STEAM BOILER USERS"

The Bird-Archer Company
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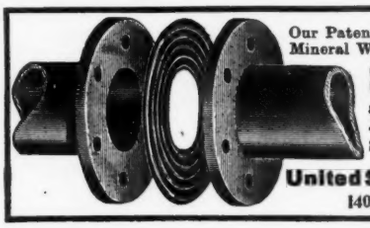
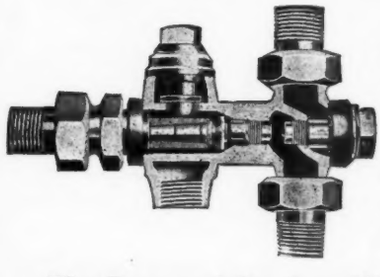
THE HAWK-EYE BOILER COMPOUND NEVER FAILED.

See our Advertisement in First Issue Every Month.
HAWK-EYE COMPOUND CO.,
303-304-305 Merrick Block, CHICAGO, ILL.



Our Patented Mineral Wool **Pipe Covering and Copper Gaskets** Save Steam and Make Absolutely Tight Joints. Best and Cheapest. Samples Free.
United States Mineral Wool Co.
140 Cedar Street, New York

The Desmond Automatic Injector
The Acme Of Simplicity



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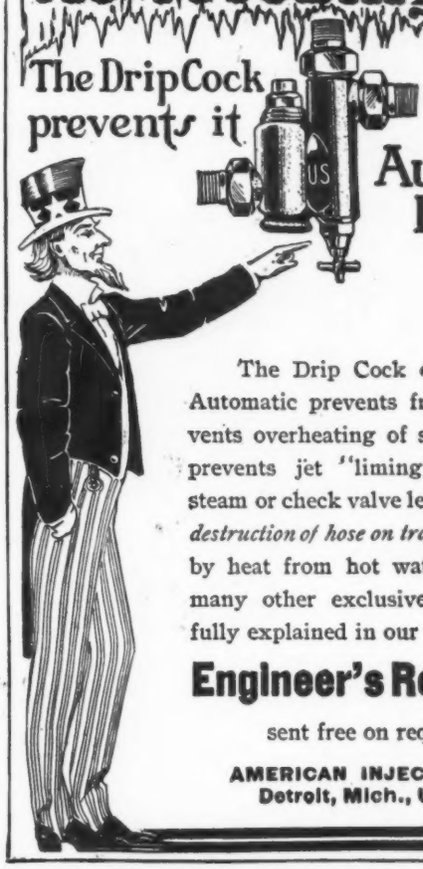

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The Drip Cock of the U. S. Automatic prevents freezing; prevents overheating of suction pipe; prevents jet "liming up" when steam or check valve leaks; *prevents destruction of hose on traction engines* by heat from hot water, and has many other exclusive advantages fully explained in our

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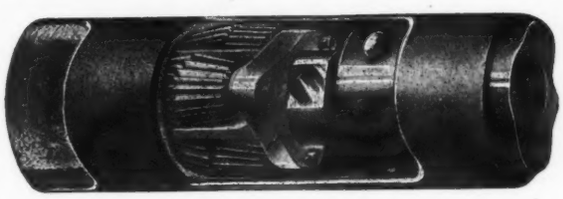

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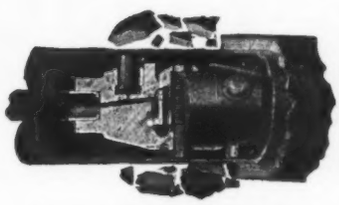

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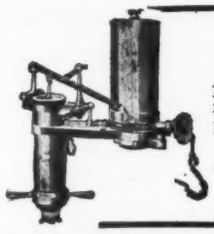

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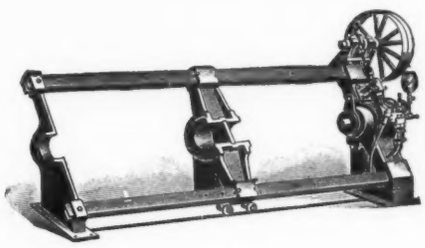

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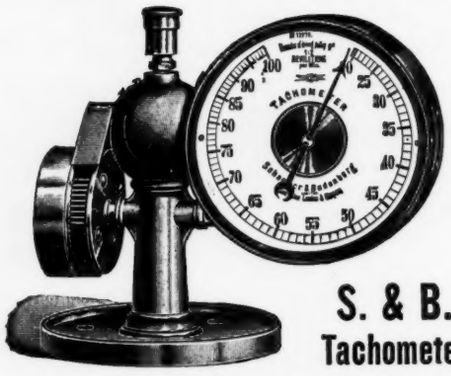

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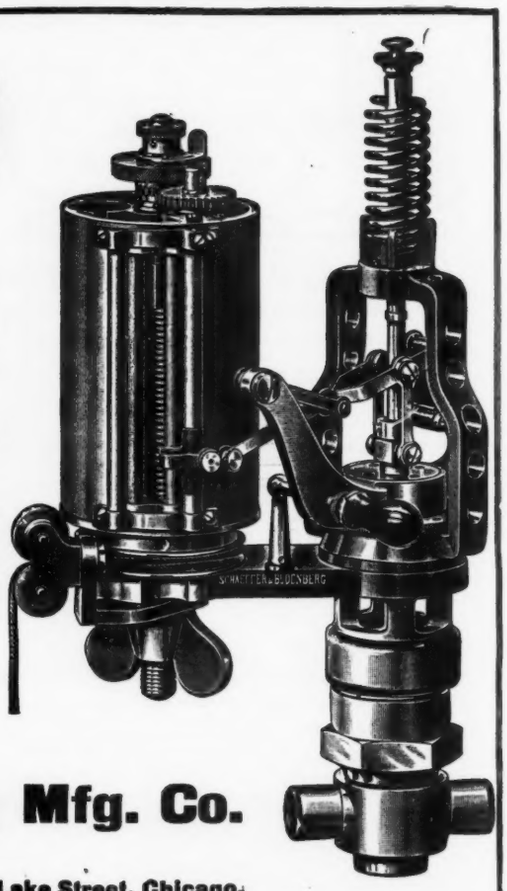

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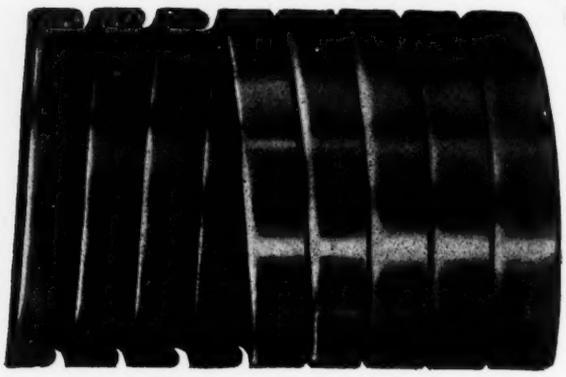

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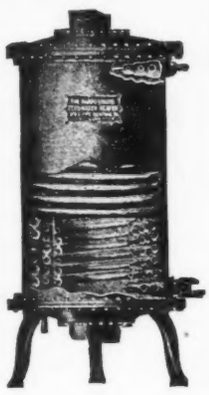

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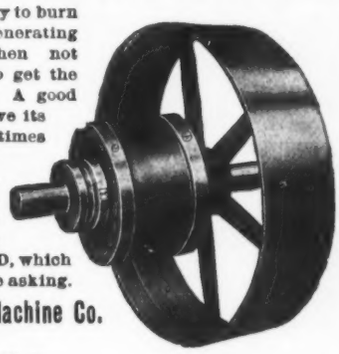

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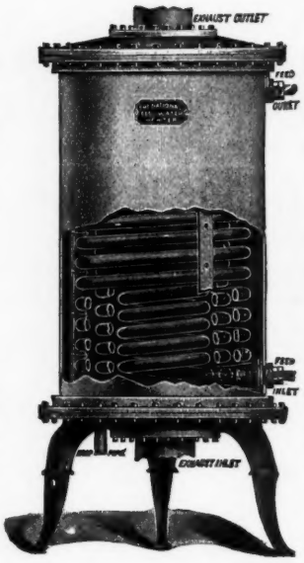

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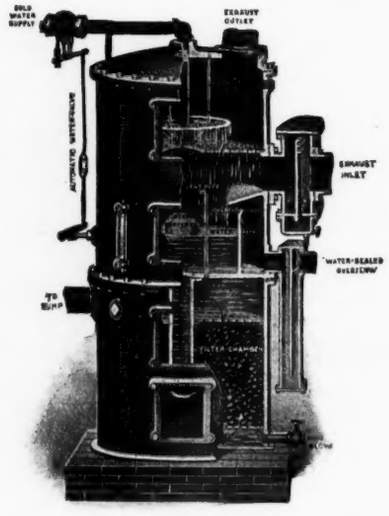

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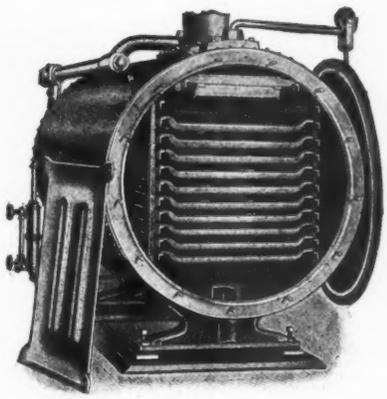

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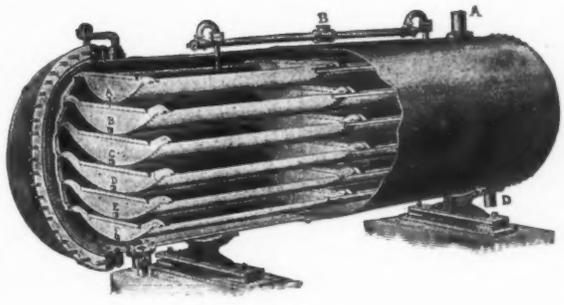

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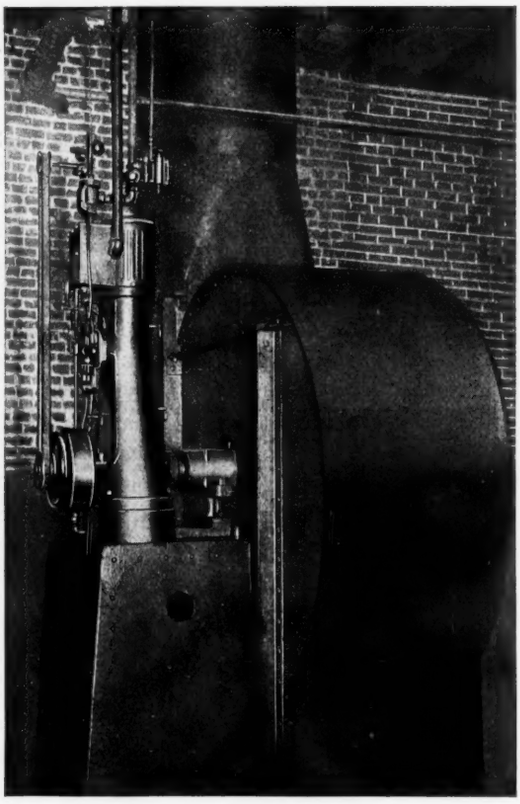

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Most boilers can evaporate twice the amount of steam called for by their H.P. ratings, and with good efficiency, as has been demonstrated over and over again. The limitations upon most boiler plants lie in the draft arrangements. A strong draft may be required only during certain periods of the day or the year, yet to provide this by chimney means a big investment, while it can be provided with a mechanical draft fan simply by speeding up the fan. Moreover, the fan gives a greater range of intensity and volume of draft than can be provided in any chimney, and with suitable automatic arrangement, the draft can be as nicely controlled as may be desired.

Where chimneys are already installed, the efficiency and capacity of the plant can be greatly improved by a Green Forced Draft Outfit. Where there is no chimney, a Green Induced Draft can be installed. For the very best results, and to prevent leakage of air into the boiler setting or of gas outwards, a combination of forced and induced draft or chimney may be applied.

By these means the most perfect combustion may be obtained with the least smoke, without excessive air supply, and, therefore, with higher efficiency. Low grade coal can be utilized to reduce the unit cost of power. Further, the capacity of the existing plant will be increased and rapid and excessive variations in the demands on the boiler can easily be met.

Send for treatise "108 P" on Mechanical Draft.

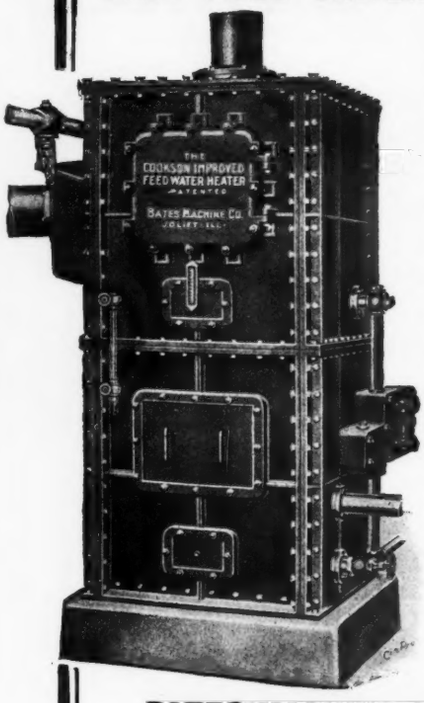
The Green Fuel Economizer Co.,

MATTEAWAN, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green's Fuel Economizers, Fans, Blower and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 175

COOKSON STANDARD ALL CAST IRON FEED WATER HEATERS



Highest Temperature and Positive Purification of feed water.

Perfect Separation and Removal of Oil.

Automatic Control of Cold Water Supply.

Dry Steam for Heating Purposes.

Finest Grade Special Fittings.

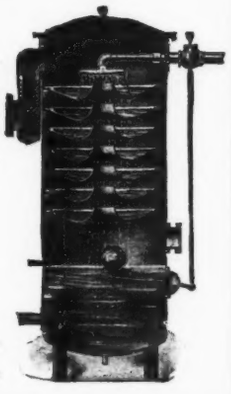
Lime Catching Pans. Especially Adapted for use with Heating Systems, Dryers, Etc.

Write for our new Heater Catalog.

BATES MACHINE COMPANY

Sole Manufacturers **Joliet, Illinois**

The Wickes Heater



Exhaust steam utilized for heating water for boiler feed or laundry work.

Simple, effective, durable. Tested like a boiler.

The Wickes Boiler Co.

MAIN OFFICE AND WORKS:

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SALES OFFICES:

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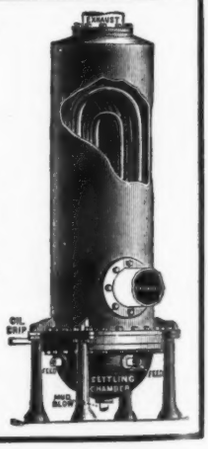
1139 American Trust B'ld'g, Chicago, Ill.
Penobscot B'ld'g, Detroit, Mich. Empire B'ld'g, Pittsburg, Pa.
601 Brown-Marx B'ld'g, Birmingham, Ala.

We'll Pay For Your Trial of the Patterson-Berryman Heater and Purifier



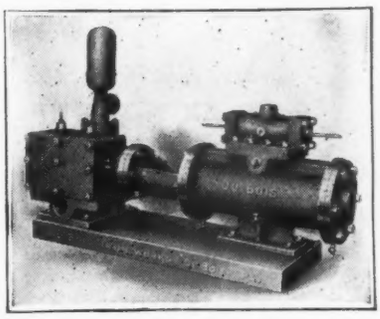
so that you can assure yourself of its value without risking a penny. Write for the trial offer and our catalog.

Frank L. Patterson & Co.,

28 Cortlandt St., New York, U. S. A.

DuBois Pumps

Only One Valve



and in all other respects

Unequaled For Simplicity

There are no outside valve gears to bend or bind.
All working parts are completely covered.

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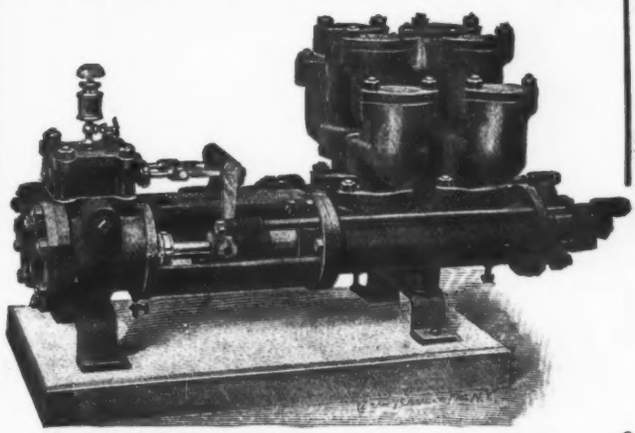
DU BOIS IRON WORKS
Established 1877
805 Brady Street Dubois, Penna.

BLAKE
PUMPING MACHINERY



Duplex Outside End Packed Plunger Pump For 300 Lbs. Maximum Pressure.

We manufacture Steam and Power Pumps for every possible variety of service for use in

POWER STATIONS—REFRIGERATING PLANTS
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THE GEO. F. BLAKE MANUFACTURING CO.
115 BROADWAY, NEW YORK
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WARREN STEAM PUMP CO.
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PUMPS FOR ALL REQUIREMENTS.

PISTON HYDRAULIC *DEEP WELL PLUNGER* *VERTICAL POWER*

Air Pumps and Jet Condensers,

Combined Air and Circulating, and Marine.

CATALOG?

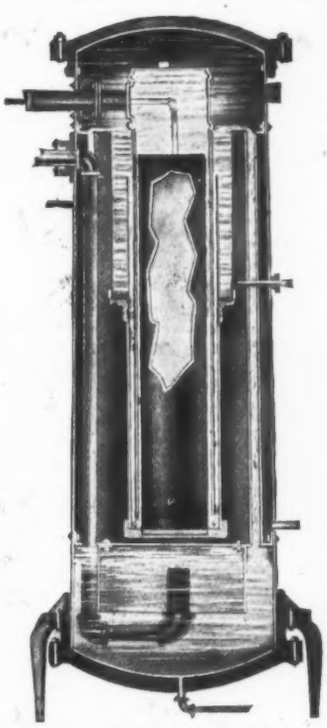
New York Office, 95 Liberty St.

Clean Boilers

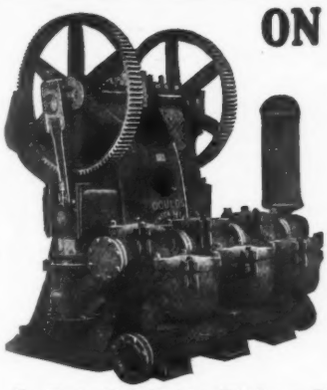
can be yours; there's no excuse for not having them. Scale is an unnecessary and expensive evil that can just as well as not be prevented.

The Eclipse Feed Water Heater and PURIFIER

uses the live steam to heat the feed water to a temperature of 300° F. At this degree the scale forming impurities are separated *before* the water enters the boiler. Less fuel is demanded too. *Catalog?*



The Eclipse Feed Water Heater & Purifier Co.
Oshkosh, Wisconsin.



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of their extremely low cost of operation and the small amount of attention required

Goulds Efficient Power Pumps

are growing in favor wherever they are installed. Let us send you Catalog of Pumps for every service.

The Goulds Mfg. Co.
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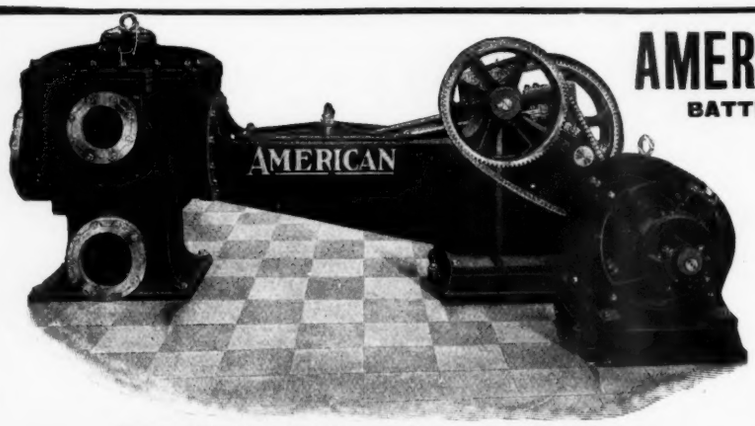

American Electric Driven Vacuum Pump. Silent Chain Drive.

AMERICAN STEAM PUMP CO.

BATTLE CREEK, MICH., U. S. A.

Manufacturers of
MARSH and AMERICAN STEAM and POWER PUMPING MACHINERY
for Every Service.

We make a specialty of VACUUM PUMPS, both STEAM and POWER, for heating systems.

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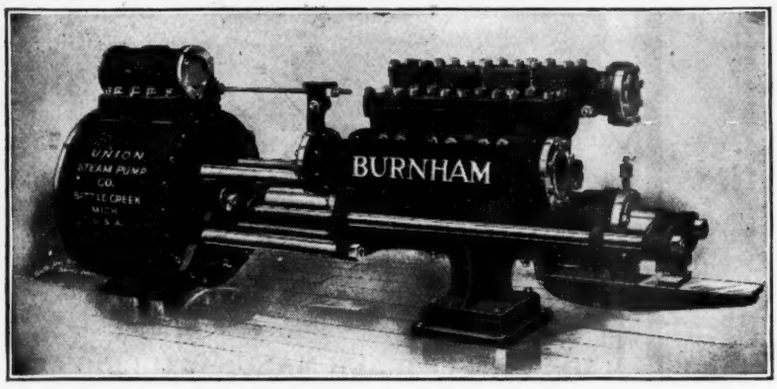
SIMPLEX NOT DUPLEX.
To be simple is to be great.



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GREAT BURNHAM Steam Pumps

WILL NOT SHORT-STROKE

Steam, belt and Motor-driven
to meet every requirement.

Buy a "Burnham" and Save Money

Made by the
UNION STEAM PUMP CO.
Battle Creek, Mich.

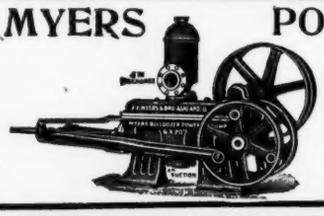
Dean Bros. Steam Pump Works

Simple Plunger Pump

INDIANAPOLIS

Simple and Duplex Boiler Feeders. Jet and Surface Condensers. Power and Electric Pumps.

MYERS POWER PUMPS

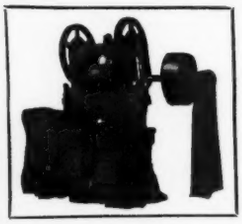


Adapted especially for gas engines, motor and belt powers, in harmony with present requirements.
Catalog sent on request.

F. E. Myers & Bro.,
Ashland, Ohio, U. S. A.

Deming

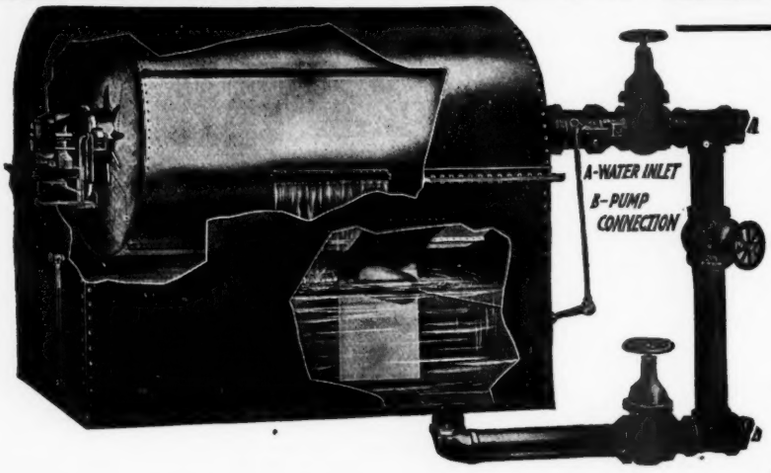
Ask for Catalogue "G" and treatise "Feeding Boilers."



For any service. **Power**

For operation by any power. **Pumps**

The Deming Company
Agencies in Principal Cities
Salem, Ohio



What Are Your Boilers Doing?

Are you getting the best economy?
Is your coal best fitted for your purpose?
Can You Tell Your Evaporation?
A

DETROIT METER

Will Give You a Continuous Record of Your Boiler Feed Water

Built in all sizes for all requirements of power plants, heating companies and for measuring any liquid.

CENTRAL STATION STEAM COMPANY
Detroit, Mich., U. S. A.
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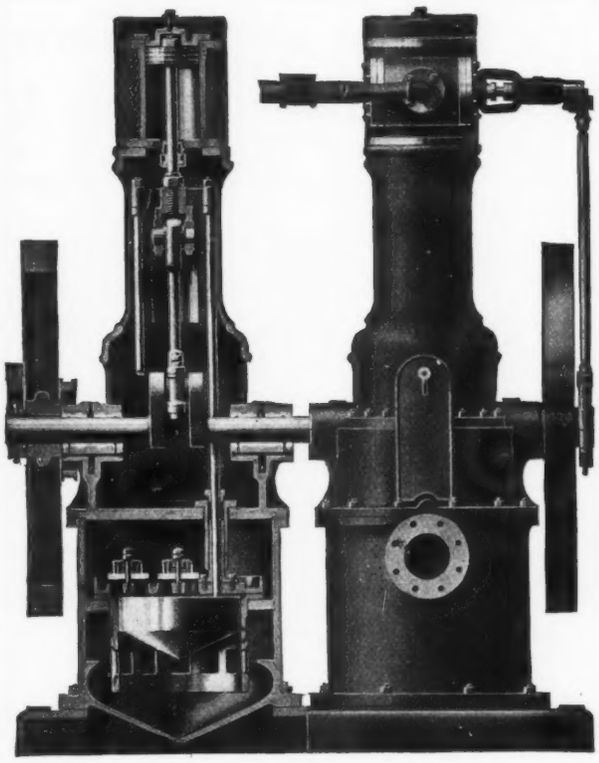


HOW DO YOU FIGURE AIR PUMP DISPLACEMENT?

A common rule is to make the volume swept by the air pump equal to 1-23d of the volume swept by the low pressure cylinder.

But what is the volume swept by the air pump?

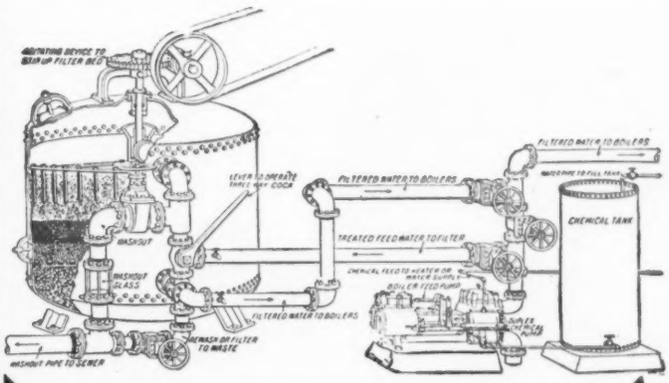
If there is a clearance space left filled with air and vapors at the delivery end of the stroke, these vapors must expand again from atmosphere down to condenser pressure before any gases can flow into the pump cylinder from the Condenser. Not only that, but if the air pump has foot valves, the gases in the pump cylinder must expand still further until the difference in pressure between the pump cylinder and condenser is sufficient to lift these foot valves. Not until this point is reached does the pump begin to do its proper work in drawing air and vapor into the Condenser, and only the remaining part of the stroke should be considered in figuring the volume swept by the air pump piston.

We wish, now, to draw your attention to an air pump that is not subject to these limitations. The illustration shows a duplex Wheeler-Edwards Suction-valveless Air Pump. At the delivery end of the stroke the air and vapors are forced out through the delivery valve AHEAD of the water, no gases therefore remain for re-expansion during the return stroke.

Again, when the plunger reaches the bottom of the stroke, the pump chamber is in free communication with the condenser, and the condensation which has accumulated at the bottom of the cylinder is injected in above the plunger in such a manner as to have an aspirating action and to slightly compress the air and vapors there just when the plunger closes the ports on the return stroke. This pump is therefore able to give as high vacuum as any combination of high vacuum pumps, condensation pumps and air coolers. It is being used in several of the largest steam turbine installations in this country.

Submit detailed particulars in regard to your plant and we shall be pleased to prepare a lay-out and make an estimate. Ask for "Bulletin 3P."

WHEELER CONDENSER & ENGINEERING CO.,
CARTERET, N. J.



THE KEYSTONE
Pressure Filter System

is sold under this positive guarantee:

That it will remove all vegetable and mineral impurities from any water.

That boilers using feed water so treated will remain free from foaming, scale or corrosion.

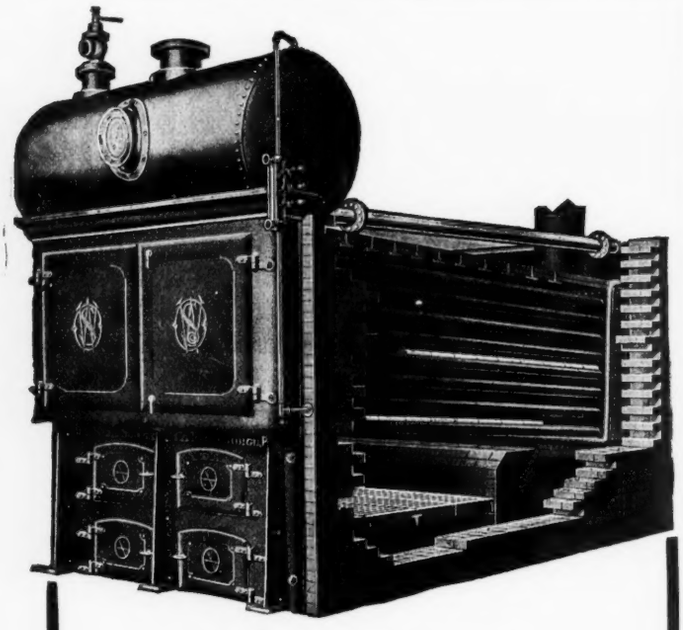
That if the KEYSTONE PRESSURE FILTER SYSTEM fails to fulfill these conditions it will be removed without cost to the customer.

OPERATION.

The diagram above shows a complete installation. Observe its compactness, and the absence of settling tanks or other cumbersome accessories. Its operation is absolutely positive. Nothing is left to chance. The water to be purified is subjected to careful chemical analysis; its dissolved impurities determined and a chemical agent provided that will precipitate itself and the dissolved impurities together, as insoluble matter. In this form it is filtered out together with the suspended impurities, leaving a pure, harmless water to enter the boilers.

Complete information supplied on request.

The Keystone Chemical Mfg. Co.
Philadelphia Chicago San Francisco



The Basis Of Economy

in any power plant is the boiler system. If you appreciate that fact you will do well to investigate

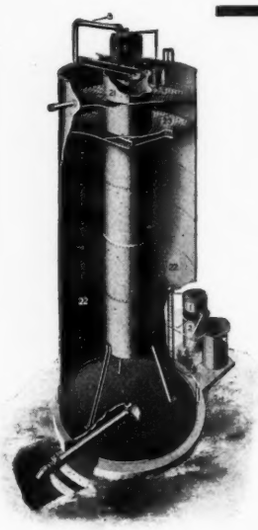
Our Safety Water Tube Boiler

Built for any pressure from 125 to 300 pounds. Meets all the high duty requirements of modern triple and quadruple expansion and compound engines. Perfect circulation, remarkable economy, and freedom to expand and contract, are features.

Ask for illustrated catalog and latest test report.

Oil Well Supply Co.,
Pittsburgh, Pa.
Boiler Works Dep't., - - OSWEGO, N. Y.
Branch Offices—NEW YORK, PHILADELPHIA.

It's Easier Not To Have Scale Than To Have It



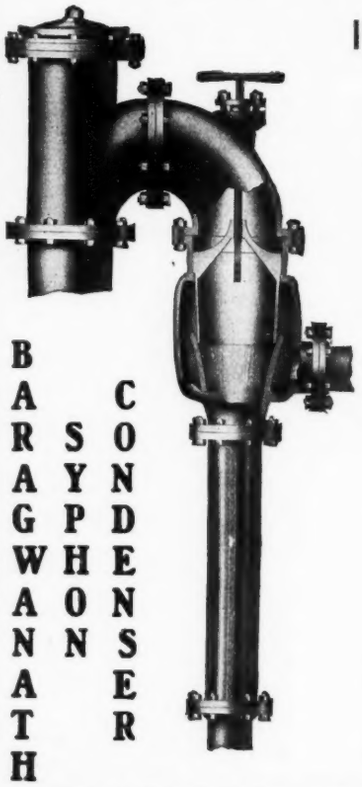
By installing the Bartlett Water Softening System, you positively prevent scale from forming by removing from the water all trace of **"hardness,"** which is a sign of scale-forming impurities.

If you continue to feed your boilers hard water, you are actually *forcing* scale upon them. Then you have to resort to injurious cleaners to get it out. So why put it in?

Write for Catalog.

Northern Water Softener Co.
Madison, Wisconsin.

Good Points



BARAGWANATH SYPHON CONDENSER

INCREASES ENGINE POWER

DECREASES COAL COST

AFFORDS CLOSE REGULATION

REQUIRES NO AIR PUMP

BOOKLET?

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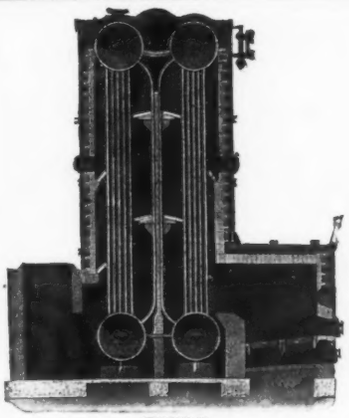
Thomas B. Whitted, Piedmont Bldg., Charlotte, N. C., Southeastern Manager.



TYPE B

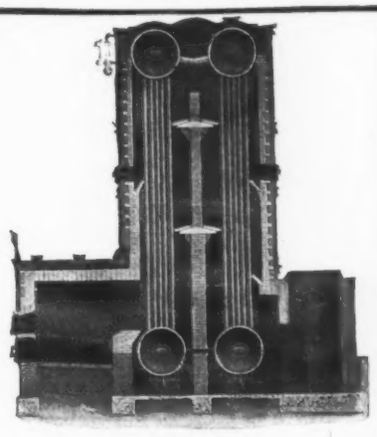
THE RUST
WATER TUBE
BOILER

SAFE, SIMPLE, DURABLE,
ECONOMICAL, ACCESSIBLE

Write for Report of Tests by William Kent.

THE RUST BOILER CO.,
PITTSBURGH, PENNA.

THE RUST ENGINEERING CO., Southern Agents | Birmingham, Ala. | New Orleans, La.



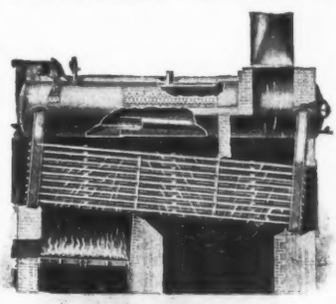
TYPE C

CONTRACTORS.
CENTRAL STATION HEATING.

Write for valuable information.

AMERICAN DISTRICT STEAM CO.,
Lockport, N. Y. Toronto, Can. Chicago.

Water Tube Boilers



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ESTABLISHED 1865.

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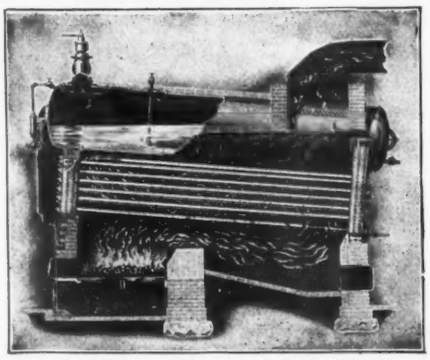
FRANKLIN WATER TUBE BOILER



BUILT BY
FRANKLIN BOILER WORKS CO.,
TROY, N.Y.

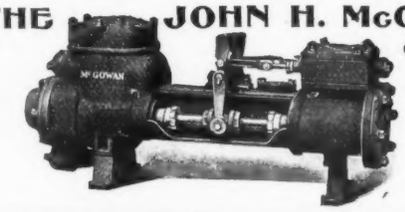
SALES OFFICE
39 Cortlandt St.,
New York, N. Y.

HEINE BOILERS
(Water Tube)

All flange steel construction.
Shipped from the shop completed.

BUILT ONLY BY THE
Heine Safety Boiler Co.
ST. LOUIS, MO.

THE JOHN H. McGOWAN CO.



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Builders of
PUMPING MACHINERY
Single Duplex and Fly-Wheel Types
Water Works Pumping Engines

PARKER BOILER CO.
WATER TUBE BOILERS—SUPERHEATERS.
PHILADELPHIA, PENNA.
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Edge Moor Boilers
—WATER TUBE—
EDGE MOOR IRON CO., Edge Moor, Delaware

Large Units a Specialty.

Send for Catalog S.

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS—MECHANICAL STOKERS

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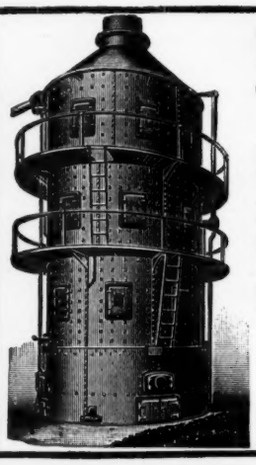
Havana, Cuba—116½ Calle de la Habana
Los Angeles—Trust Building
Cincinnati—Traction Building



Fuel Economy

THE large heating surface of the CLIMAX BOILER and its ability to utilize every particle of heat enable it to produce more steam per pound of coal than any other type or make. It supplies steam absolutely dry and superheated to over 80 degrees. Full description in our booklet. Write.

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Main Offices: 250 Lorraine Street.

Works:
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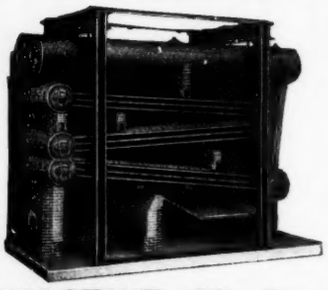
Telephone, 243 Hamilton.

Rapid Circulation

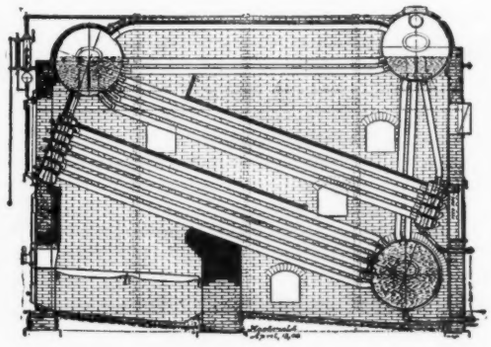
Puts an End to Scale.



In Vogt Boilers the feed water has to pass through three banks of tubes before entering the steam drum. Circular ?

HENRY VOGT MACHINE CO., Inc.
LOUISVILLE, KY.

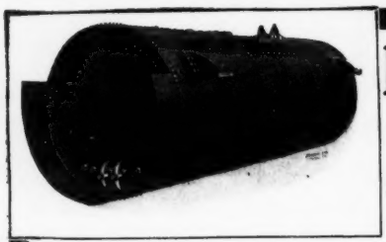
Robb-Mumford Water Tube Boiler



Free expansion of tubes—Perfect water circulation—Dry or superheated Steam—Half the usual number of handholes.

Robb-Mumford Boiler Co.,
South Framingham, Mass.

New York Office, 90 West Street.
Built in Canada by Robb Engineering Co., Ltd., Amherst, N. S.



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Are Boilers of CHARACTER

They bear the mark of superiority. They are built by mechanics, are strong, solid, substantial, efficient, durable. Have the name KEWANEE in your specifications.

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KEWANEE, ILLINOIS.

Alberger Condenser Co.

Condensers, Cooling Towers, Vacuum Pumps, Heaters

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New York

Centrifugal, Volute, and Turbine Pumps

Alberger Pump Co.

Leave It To Us

We will send men and portable tools, make the engine repairs on the spot quickly, cheaply and satisfactorily.

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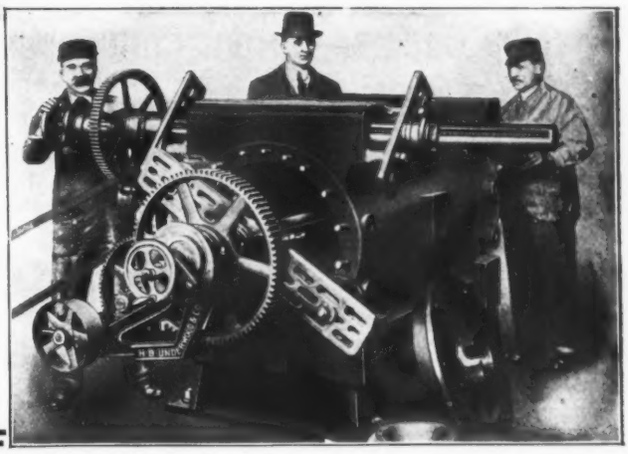

Any Pressure

UP TO 8,000 LBS. PER SQ. INCH can be positively and automatically controlled with the

FISHER PUMP GOVERNOR

For use in Hydraulic Service, Air Compressors, and all types of Pumps working under pressure. *Sold under guarantee to satisfactorily perform its work. Write if interested.*

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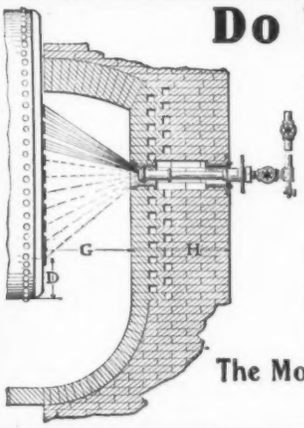

how much coal is wasted in your plant every day owing to soot accumulation in the boiler flues? It runs up into a large amount in the course of a year.

A Monarch Steam Flue Blower would stop this waste. It blows the soot in the direction of natural draft. Why not order one on trial?

The Monarch Steam Blower Co.

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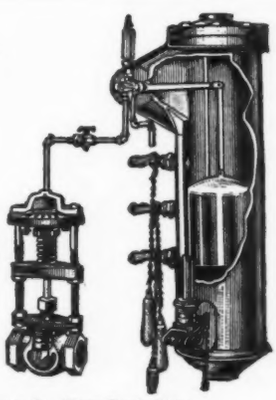
THE

BERRY

Safety Automatic

Feed Water REGULATOR

Send for Catalogue



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Chester, Penn.

Metropolitan Office, 136 Liberty St., New York City.

The Vigilant

Feed-Water Regulator

for steam boilers was the first in the *field*, and has the longest and best record of any of these devices.

Costs Less to Operate and Maintain

Constructed on a different and better principle than any other.

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Morison Suspension Furnaces

For Land and Marine Boilers

also—**FOX CORRUGATED FURNACES.**

Uniform Thickness

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Unexcelled for Strength

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Weiss Counter-Current Condenser.

We are sole licensees in the United States for the manufacture and sale of this Condenser, and will gladly send particulars to any one interested.

We guarantee any desired vacuum, using less cooling water and of higher temperature than other apparatus.

All contracts made upon positive statements as to relative volume of steam and water.

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Better Light

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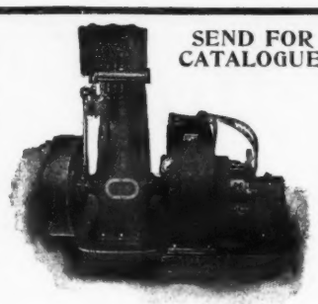

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Produce it yourself with Engberg's Generating Set. Size and power considered there is nothing to equal it on the market. Will maintain with perfect steadiness from 30 to 500 lights requiring very little steam and less of your attention. For compactness and reliability it has no equal.

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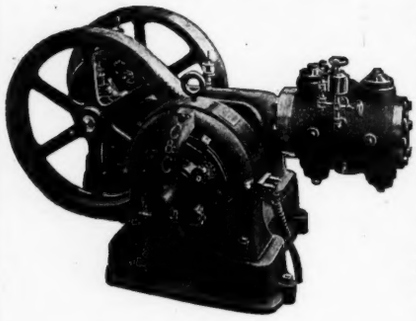

when it's working hard. No need to add to the temperature when a motor runs the outfit—select a

C & C MOTOR

the coolest running motor on the market. (Get Bulletin 158 E.)

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Agencies in all principal cities.

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20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
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Satisfaction:—

That absolute knowledge that your ice machine is producing full capacity at the minimum expense; that there is no danger of shut downs for repairs—this is the result of using Triumph machinery.

The Palmyra Ice Co., Palmyra, Mo., state—"The machine is a light steam user and the construction is such as to guarantee long life with light repair bills. In fact, our repair bills during the past season have been nothing and the machine has been used constantly all summer night and day up to Dec. 1st. Were we in need of another machine, we would duplicate it."

In addition to our unequaled compressor construction, remember we also provide you

"The fittings that don't leak."

Let us send you catalog "Triumph Originality."

THE TRIUMPH ICE MACHINE CO.
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The overload capacity of **C-W** electric generators makes them popular with the engineer. In emergencies they do better than is expected of them. Bulletin 80M describes our D. C. machines.

CROCKER-WHEELER COMPANY
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We manufacture all machinery and parts needed to equip a complete Ice or Refrigerating plant—

Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings.

of all kinds. We employ over 1,250 men in the manufacture of Ice and Refrigerating Machinery exclusively. Catalogue sent upon request.

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Individual Electric-Motor Drive

For Pumping

an electric motor is much simpler than any form of engine and the electric service is always instantly available. There are no reciprocating parts, no pistons to wear out and require packing, no dirt, exhaust steam or vibration to contend with; the motor is clean and noiseless, the bearings are self-oiling, requiring only an occasional inspection and renewal of oil.

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Westinghouse Motor Driving 6x12 Aldrich Quintuplex Pump. Designed to deliver 435 gallons per minute against 1100 feet.

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of efficiency in a transformer is service—that determines the quality of efficiency. No matter how high the efficiency may be when installed, if that efficiency can not be maintained it is of no real value.

15 K.W. Type A Transformer

The only transformer that maintains its durability and efficiency like a Type A transformer is another Type A.

They are alike in quality.

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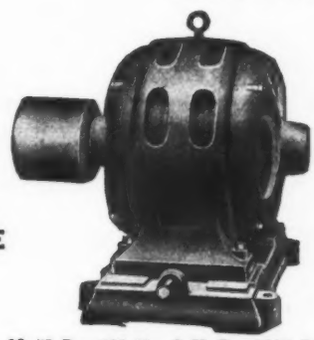

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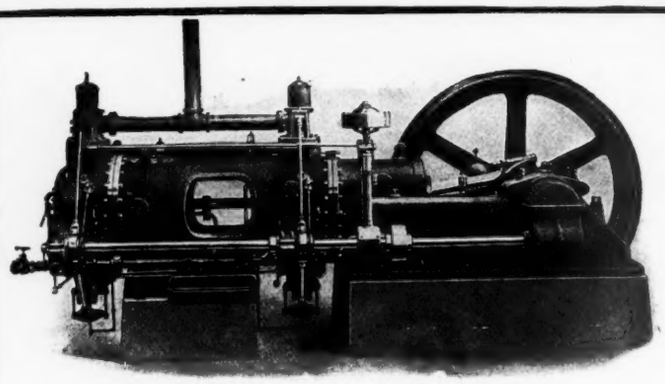

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Types up to 700 H. P.

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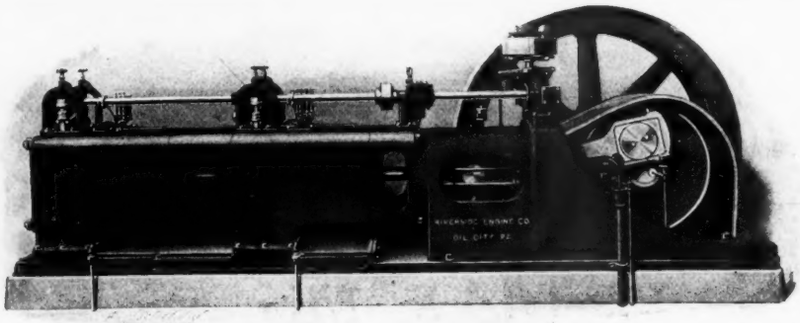

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Built in all types, single cylinder, single acting to twin tandem double acting, 40 to 2,500 H. P.

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Riverside Heavy Duty Single Acting Tandem Gas Engine (Class C)

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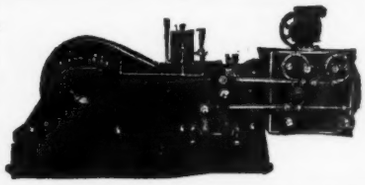

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Engines have been tried and found true—let us tell you more about them.

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Northern Type 'L' Generators for Direct Connection to Engines

Our New Type "L" Generator has no equal for economical operation due to the fact that it is MADE RIGHT. It embodies patented features not found in other makes. For instance our Trisected Laminated Pole insures perfect commutation under all loads. The Northern system of natural ventilation insures low temperature rise. Get Bulletin 855.

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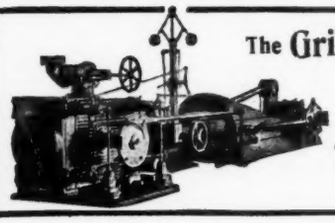

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BERRY SAFETY **BOILERS** POWER PLANTS

We Manufacture
AN ECONOMICAL AND DURABLE ROTARY ENGINE
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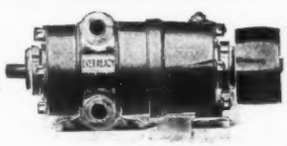

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Perhaps you have one; if so, we're content to stand by its record. If not, we'd be glad to tell you what SHEPHERD ENGINES *have done* and *are doing*. Drop us a line.

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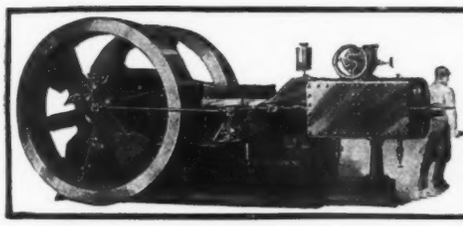

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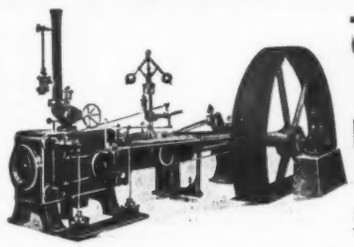

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Refrigerating and Ice Making Machinery
THE VILTER MFG. CO.
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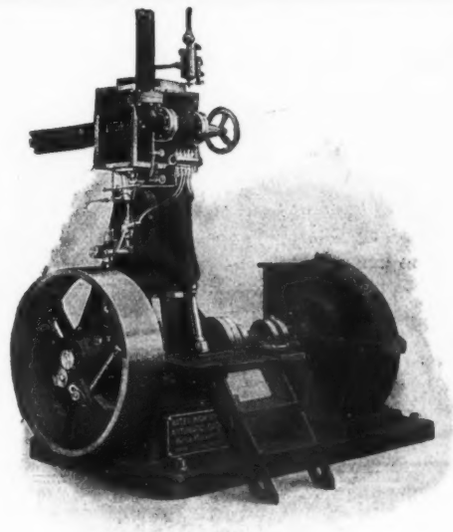

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and other places where it is desired to move a large volume of water at small expense.

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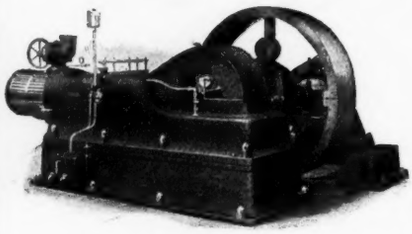

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SINGLE and FOUR VALVE

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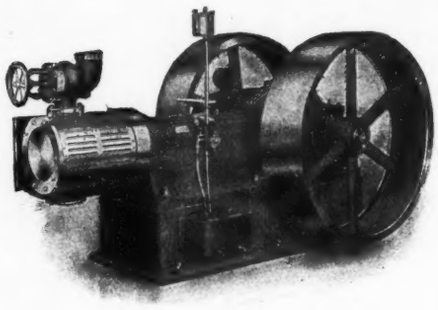

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BUILDERS OF HIGH CLASS

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HIGH IN DUTY, SUPERIOR IN REGULATION
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ABSOLUTELY RELIABLE
CORRESPOND WITH US BEFORE PURCHASING
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ALSO
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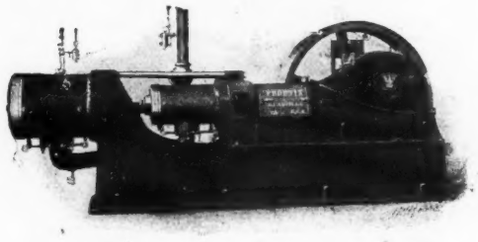

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RICE & SARGENT
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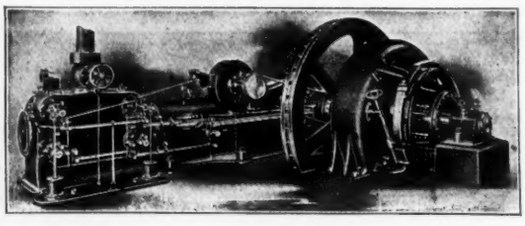

Strong and durable.
Unmatched for ease and safety of operation.
Write for a Catalogue.

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IDEAL for other purposes

The "Ideal" has made its reputation as an Electric-Light Engine; but the qualities which have made it so pre-eminent in this field, are just as essential in a *general-purpose engine.* Economy, Perfect Regulation and Simplicity ought to be the common virtues of every engine.

Simple and compound, 10—500 horse power.

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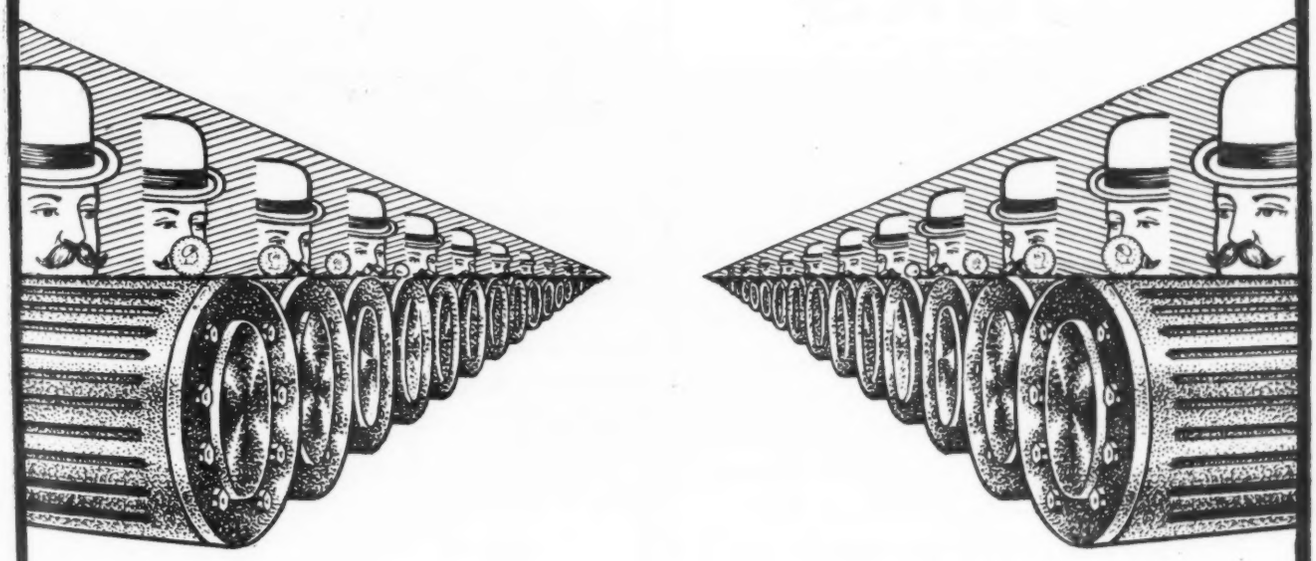
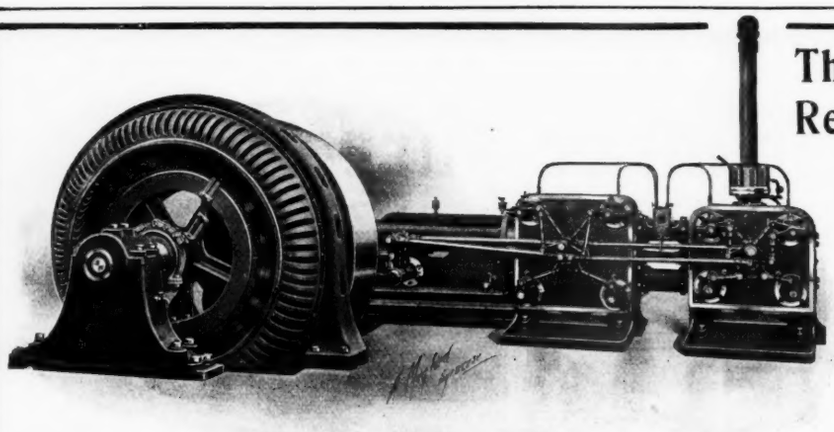


They run so true and steady that a silver dollar will stand balanced upon the cylinder under test.



This Engine Runs 200 Revolutions per Minute

High speeds, high pressures, unsurpassed economy; low repairs, the most perfect valve motion; low cost per engine horse power; still lower generator cost. The first Corliss engine we ever built run 26 years at the rate of 11 hours per day. It is still absolutely perfect and is the engine we show prospective buyers. Better investigate our engine records.

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"ERIECO"

The Engine that lasts longer and gives more satisfaction per day than any other.

CATALOG 2

Erie Mfg. & Supply Co.
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ON A MINUTE'S NOTICE

We have for immediate delivery:

One 18-inch by 42-inch girder frame engine, left hand, 90 revolutions, rated at 250 h.p.; wheel 14-ft. diameter by 48-inch face.

One 19-inch by 42-inch girder frame engine, right hand, 100 revolutions, rated at 280 h.p.; wheel 14-ft. diameter by 33-inch face.

The above are **new** engines.

One 14-ft. diameter by 28-inch face pulley, turned for belt. Hub bored 11-inches diameter. Wheel weighs 15,000 pounds.

Get busy and communicate with us.

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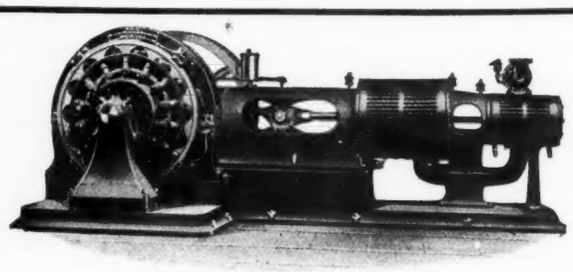

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Ridgway Generating sets cost a little more than others at first and a great deal less in the end.

RIDGWAY DYNAMO & ENGINE CO.
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Steam Turbine Motors
Steam Turbine Dynamos
Steam Turbine Blowers
Steam Turbine Centrifugal Pumps
Electric-Motor Centrifugal Pumps

De Laval Turbine-Driven Series Pump. *Send for Catalog No. 20.*

DE LAVAL STEAM TURBINE CO., Trenton, N. J.

General Electric Company

Curtis Turbine Generators Appeal To The Practical Engineer

Because

No internal lubrication is required and the exhaust steam is absolutely clean and may be turned into the heating system without risk of clogging it with oil—

Or

if the turbine is operated condensing the condensed steam may be returned to the boiler free from oil.

Because

The turbine may be brought up to speed ready to carry load almost instantly—no warming up, draining or other preliminary delays are necessary

And

the turbine is not injured if flooded with water while in operation.

Curtis Turbine Generators need only to be known to be appreciated by all.

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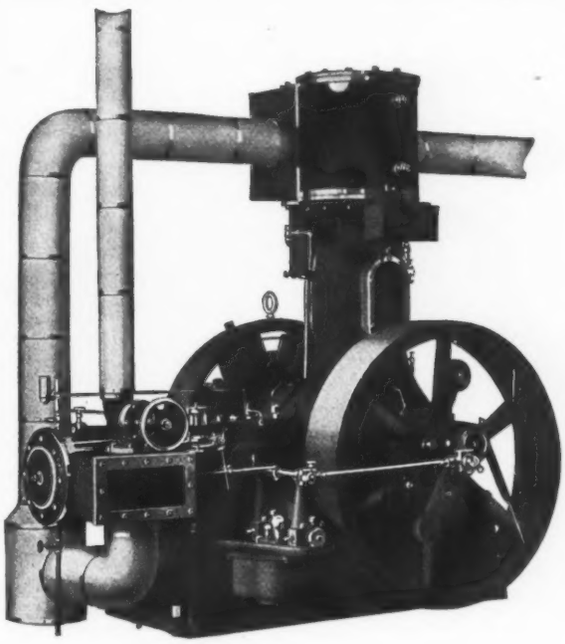

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We place no reliance upon "splash" lubrication. A direct acting pump attached to the high-pressure-valve rock shaft forces a generous stream of oil through a system of direct pipes with sight feeds to every bearing point, flooding the surfaces and reducing friction to its "irreducible" minimum.

A tank, high up on the vertical cylinder frame, is maintained constantly full (as indicated by a float and "tell-tale") so that in case of accident to the force pump there remains always a quantity of oil that will feed to all points by gravity. This tank may be filled by hand in an emergency and the engine kept running. This is a most important and valuable detail.

The new angle compound is a remarkable combination of good practical details. It will pay you to investigate. Write for details.

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Builders of American-Ball Simple and Compound Engines;
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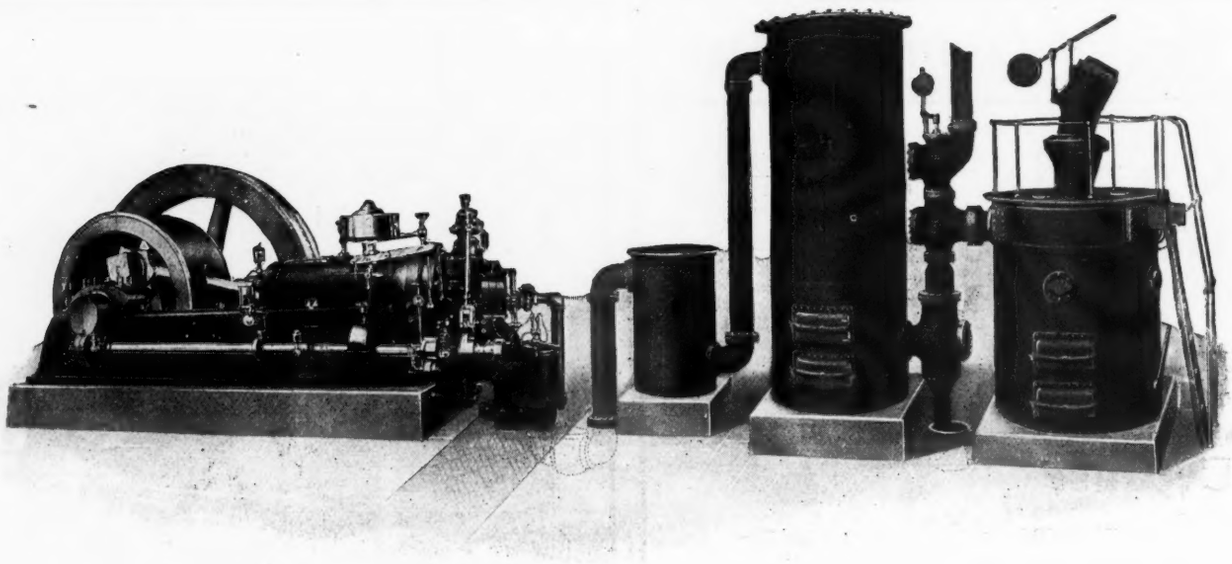

Muenzel Producer Gas Power Plant

READ WHAT A FEW USERS OF THE

Muenzel Producer Gas Power Plants

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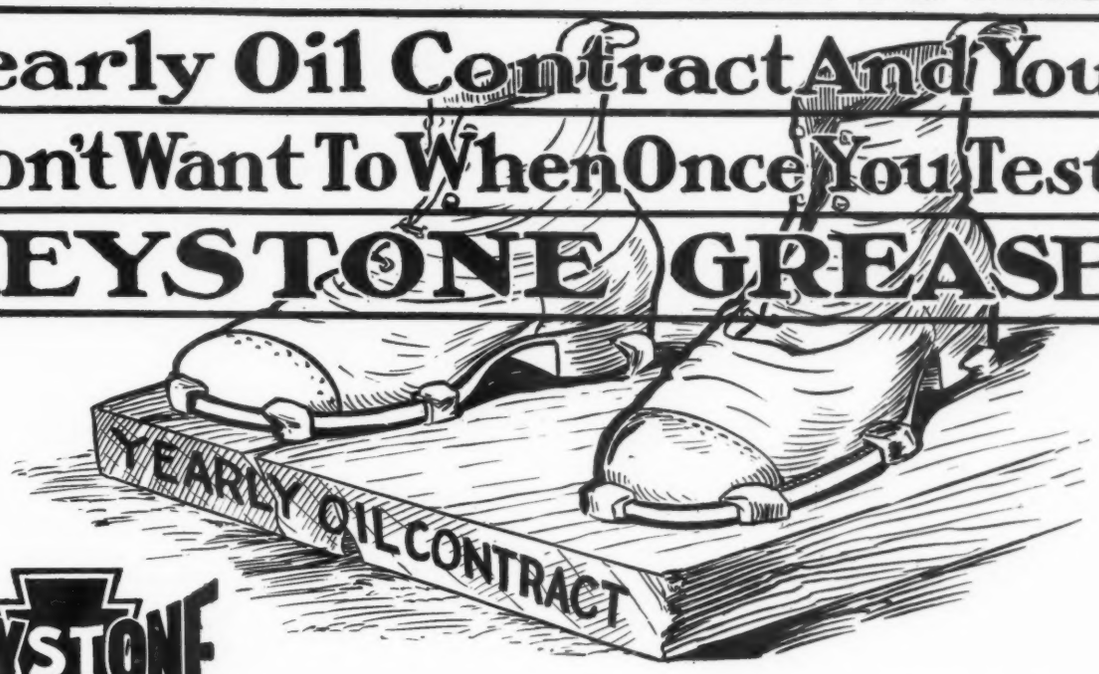

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